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SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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The Du Mont Telecentre

By R. D. CHIPP

The building now occupied by the Du Mont Telecentre was formerly the Central Opera House of New York. This paper describes in detail the process of altering the more than 80-year-old building to fit the needs of a modern TV broadcasting station and explains why this building was selected by Du Mont. The paper describes the electronic equipment used in the Telecentre and architectural problems met and solved before the equipment was installed.

The building now occupied by Du Mont Telecentre was built in 1873 and was then known as the Central Opera House. It was one of the show places of New York, and rivaled in magnificence the Metropolitan Opera House with its glittering Diamond Horseshoe.

The Central Opera House with its crystal chandeliers, enormous ballrooms and tremendous bars was built (or so the story goes) by Jacob Ruppert and some of his associates in the brewing business for the reason that they were snubbed by New York Society when they appeared at the Metropolitan Opera House. So they built another opera house.

By mid-century, the building at 205 E. 67th St. (Fig. 1) had fallen into the senility that overtakes most of the great structures of the past. At the time that Du Mont acquired the property there were, among other tenants, a school of embalming, a kindergarten and a chain grocery store.

During those days, Du Mont, like many other TV network broadcasters was looking for more space. During 1949 and 1950 camera hours at the key station in New York, WABD, channel 5, increased from 28,000 to 42,000. There are certain basic requirements for a TV broadcasting station that impose strict limitations on the selection of new quarters. For one thing, the activities of many departments should be closely integrated for reasons of economy and convenience. Sets that are designed in one place, built in a second and used in a third will be expensive because of trucking charges and lost time alone. Also, TV broadcasters need large areas of floor space capable of carrying heavy loads. High ceilings are necessary and yet there can be no supporting columns that will interfere with the mobility of production.

The old Central Opera House was found to be a well constructed building that could be modified to meet these requirements. The selection of an existing building offered an interesting bonus as a by-product. The volume of this building in relation to the plot size is much greater than could be built today with zoning regulations which require setbacks at specified intervals. Under these restrictions, a new building having the volume of the Telecentre would require a much larger plot of ground.

Construction

To architects and engineers, an alteration job is more difficult, perhaps more

A contribution submitted on May 28, 1956, by R. D. Chipp, Allen B. Du Mont Laboratories, Inc., 35 Market St., East Paterson, N.J. This paper describes what has been demonstrated on various engineering tours, the most recent having been that for this Society on April 30, 1956. Some of the equipment details were described at the NARTB Engineering Conference at Chicago, May 1954

Fig. 1. The Central Opera House before conversion.

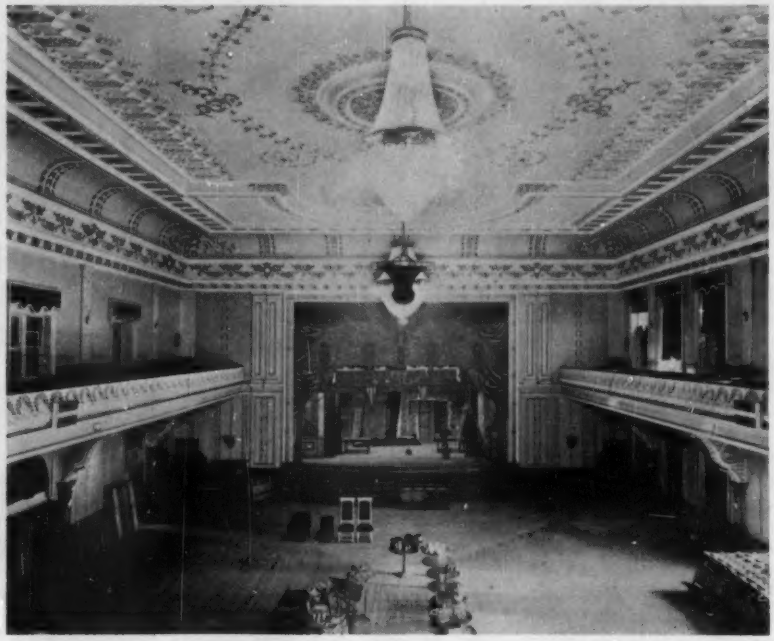

Fig. 2. The Grand Ballroom before demolition; view from the balcony.

Fig. 3. Telecentre Ballroom during conversion to Studio 5; view from top level looking East.

of a challenge, than a new construction. Seven sets of plans were considered before a decision was made. The plans finally approved called for five live studios, two nemo studios, master control, film projection, video and audio recording, engineering offices, program and operation offices, and all needed ancillary services such as prop construction and storage, air-conditioning plant, maintenance shop, dressing rooms, etc.

Figure 2 shows the ballroom before demolition with its vast ceiling and baroque decor. Figure 3 shows the ballroom after the floor had been removed. New steel was passed through the old windows, which were then bricked over; and the old ballroom took on its present form as Studio 5. The freight elevator, which is fed from the loading platform at street level, connects directly into each studio through a sound lock. It has a capacity of 10,000 lb which makes it possible to carry automobiles and small elephants as well as the more usual props needed for a wide variety of programs. The studio shown in Fig. 4 is over 100 ft long, 75 ft wide and 40 ft high. The taxicab, brought up in the freight elevator, is almost lost in the vast expanse of space. The floor surface of the studio is $\frac{3}{16}$ in. sheet rubber, which comes in rolls 4 ft wide. Sheet material seems to be more satisfactory than tile as tile tends to catch or pick at the many individual corners or joints when heavy equipment or sets are dragged over it. The floor slab itself consists of high-density concrete, covered first with a 5-in. thick fill of lightweight cinder concrete, over which, in turn, is a $1\frac{1}{2}$-in. layer of cement finish. The floor must be as smooth as it is possible to make it before the sheet rubber is applied. When a camera is dollied over bumps or irregularities, it is noticed as sudden movement on the receiver screen.

This type of floor construction has several advantages. For one thing, the lightweight fill serves as a medium in which to place conduit for wiring, and also it helps minimize sound transmission between studios located one above the other. The sheet rubber combines resilience with toughness, and is relatively easy to clean. The color of the rubber flooring is a medium gray that reflects a minimum amount of light, yet provides a neutral background or foreground when in the picture. Appropriately placed markings of water-base paint can transform this plain floor into a flagstone terrace or a cobblestone street.

The floor is designed for a live load of 125 lb/sq ft in order to permit the use of heavy sets and props such as automobiles. (A normal residence has a floor loading of 40 lb/sq ft.) In a multistory studio building this high design load poses a problem for the architect and engineer, because the use of columns to support the floor above must be kept to a minimum.

Sound Control

The audio problems in a TV studio are twofold, and involve both sound isolation and minimum reverberation time. To a degree they are more difficult in TV than in AM, for the reason that, in most cases, microphones should not appear in the picture. As a result, microphones are from 4 to 10 ft from the performers, and the gain of the associated amplifiers is correspondingly high. These factors cause a high ratio of reflected sound to direct sound, and increase pickup of unwanted sounds. To offset these effects, reverberation time should be as low as possible, and every step should be taken to reduce ambient noise. In order to deaden our studios, the following sound absorbent treatment was used: From 3 ft above the floor to approximately three-fourths of the studio height, 1-in. Banacoustic batts, protected by mesh, were applied on all wall surfaces, and the walls above the batts and all ceiling surfaces were given a coating of Asbestospray.

Care must be taken to isolate conduit and duct work to avoid sound transmission. Air ducts are lined or provided with sound traps. Walls may have to be of double construction, particularly between studios; and sound locks are utilized at all studio entrances.

Rigging and Lighting

Counterweighted battens are liberally sprinkled over the ceiling, and are used to support sets, drapes and lights. This technique was borrowed from the legitimate theater. A batten is a pipe, supported by cables which pass over pulleys on the ceiling, which are in turn connected to a carriage that rides vertically on guide cables pulled taut along one wall of the studio. The load on the batten

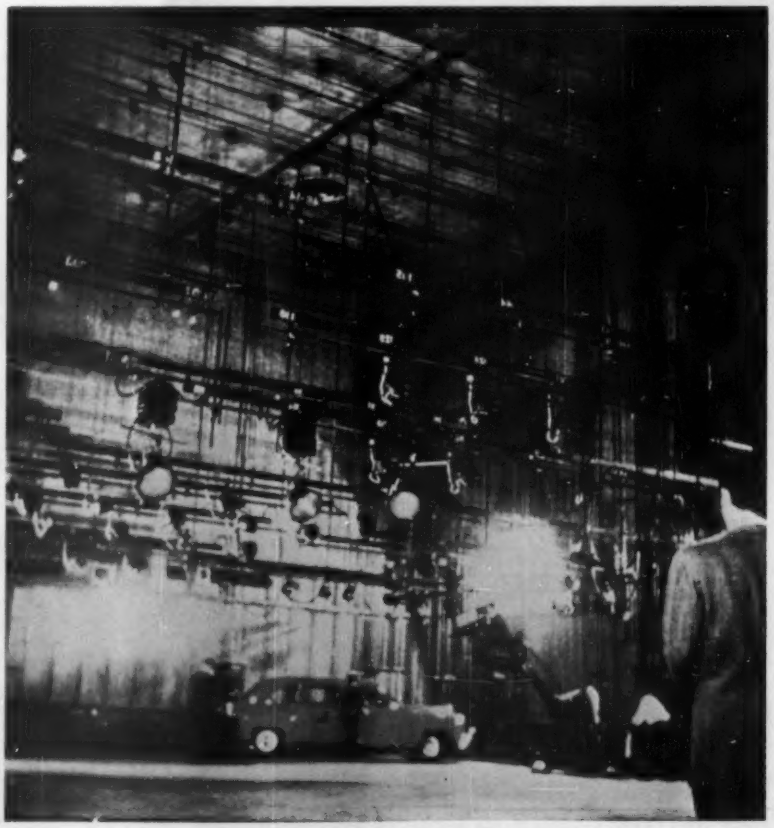

Fig. 4. Studio 5; on stage is a taxicab.

is balanced by placing weights on the carriage. A continuous loop of rope fastened to the carriage passes over pulleys on the floor and ceiling, and is used to adjust the height of the batten. In a TV studio the battens are usually spaced between 2 and 4 ft apart, and provide extreme flexibility for setting and lighting any type of program.

Figure 5 shows two basic types of lighting, scoops and spots. The scoops accommodate 1000-w or 1500-w lamps, and the spots vary from miniature 100-w babies to the massive 5-kw units. TV lighting is a subject in itself, and a most important one. Poor lighting can seriously detract from the technical as well as the artistic quality of a program. For example, if the range of light from the brightest part of a scene to the darkest part of a scene is too great, the dynamic range of the TV system may be exceeded. The effect is to saturate the whites, or the blacks, or both. This condition can be simulated at home by turning up the contrast control too far. This type of saturation means that much detail is lost, and that the scene is not accurately reproduced in respect to shades of gray. Pictures of singers in a circle of light from a high intensity spotlight with the features so washed out that the face has no recognizable characteristics are often seen. A few directors seem to like this effect. The human eye can accommodate itself to a wide dynamic range; the TV system cannot. We try to stay within a contrast range of approximately 20:1.

Even if the lighting is technically correct, it may be poor from the artistic standpoint. Since television, at present, is a two-dimensional medium we must use lighting to create the impression of the depth dimension.

At the Telecentre the lights are controlled by a thyratron-type system, manufactured by Century Lighting Inc. which consists essentially of three major units — the patch panel, the tube bank and the control console. Each numeral that appears on the battens represents a flexible cord and connector that can be plugged into a light fixture clamped to the batten. When this connection has been made, the circuits to that particular fixture appear on a cord in a patch panel. The patch cord is used to associate a fixture, or a group of up to four fixtures, with either a dimming circuit or a switching circuit. The grid control circuits for the remotely located thyratrons are brought to a small, finger-tip control console located in the studio control room area. Once the lighting for a program is determined, the fixtures are patched electrically, and positioned physically. From then on, all control is from this console. On a series of relatively simple programs that may follow one another in the same studio it is quite practical to set up all the lighting in advance.

Air Conditioning

With all this light, there is bound to be heat, and indeed there is. To remove it requires an air-conditioning plant of more than normal size. Our design load for the studios was based on heat equivalent to 25 w/sq ft plus 1500 w for each rack of equipment. The total load for the building, with a diversity factor of approximately 70%, is handled by two 225-ton refrigeration units. The basic parts of the system are shown in Fig. 6. Fresh air is sucked in, filtered, and passed over steam coils and chilled water coils before being supplied to the various studios and other areas.

Because of wide variations in load conditions, there are eleven separate systems, each with its own supply and return ducts. The amount of steam or chilled water that is used will depend upon the difference between outside conditions and the desired inside conditions, which are 70 F and 50% relative humidity. The maximum hot weather conditions, upon which the system design was based, are 95 F and 85% relative humidity. Steam is obtained from dual boilers in the basement and the chilled water from the dual refrigeration units also in the basement. The water that is used to cool the refrigerant is piped to a cooling tower and then reused. This is the result of a water conservation program instituted by New York City, and many other cities after the severe water shortage in 1949.

Humidity control is obtained by chilling the incoming air to approximately 50 F, which condenses some of the water vapor. The air is then heated to approximately 65 F, at which point it will have a relative humidity of about 50%.

Another very important consideration in air conditioning for TV studios is the necessity for low air velocities to avoid the sound of rushing air which is picked up by microphones. Our specifications provided for intake and exhaust velocities of not over 500 ft/min; and duct velocities of not over 1000 ft/min. With these stipulated velocities and the volume requirements, duct sizes are large. They vary from 1 ft × 3 ft to 5 ft × 9 ft.

Fitting ducts of this size into the building ceilings and walls, running both horizontally and vertically, while retaining as much usable space as possible presented an interesting architectural problem.

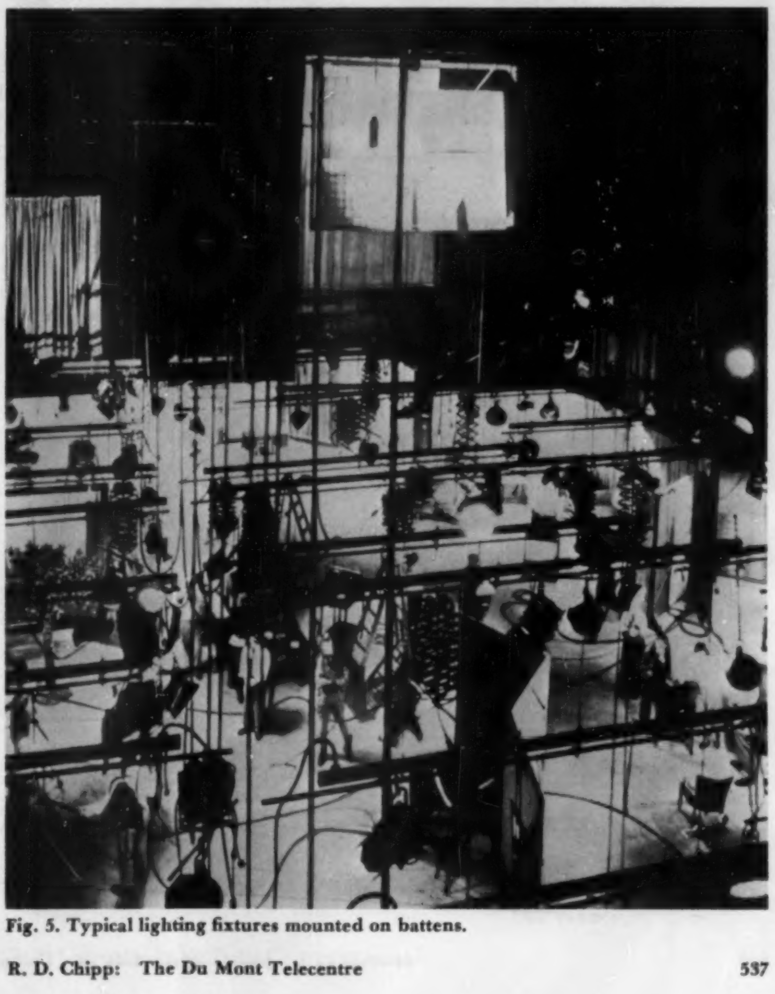

Fig. 5. Typical lighting fixtures mounted on battens.

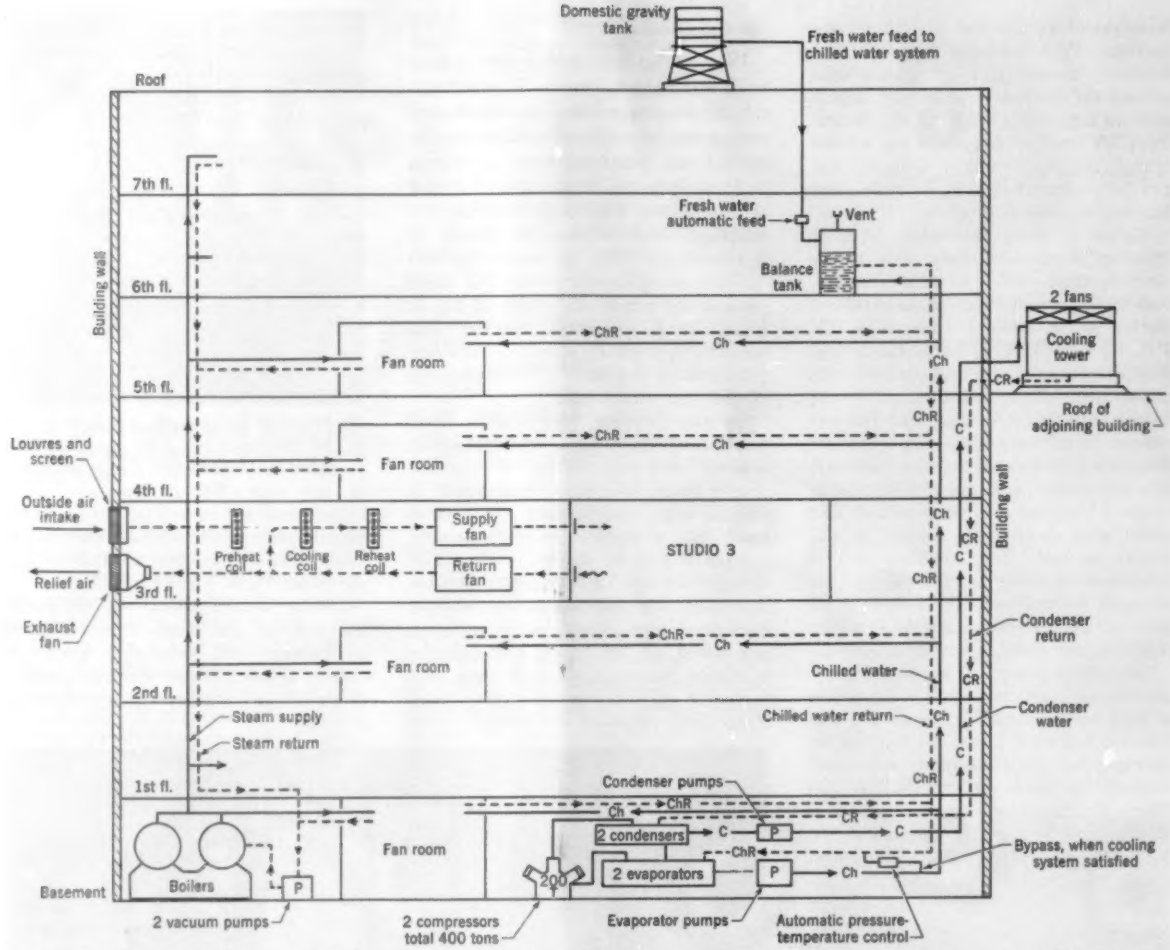

Fig. 6. Simplified block diagram of the basic parts of the air-conditioning system. The diagram shows the fan room on the 3rd floor in detail. For simplicity, the steam and chilled water connection, to the heating and cooling coils are not shown. All fan rooms in the building have corresponding equipment and design.

Power

In view of the necessary ventilating equipment and lighting equipment, power source is an important consideration. Figure 7 shows a diagram of a-c primary power. The total capacity available is 3000 kva, from three separate sources. This is distributed, as shown, at 120/208 v, 3-phase, 4-wire, to three separate services. Service A, with a capacity of 2500 amps per phase, feeds all of the lighting equipment in the studios. Service C has a capacity of 2500 amps and feeds all of the electronic equipment in the studios and control rooms. Service B, 3000 amps, feeds the major rotating equipment, elevators, fans, compressors, etc. Isolation between services that feed electronic equipment and rotating equipment reduces surges when heavy equipment is turned on and off. In addition, we have d-c service available if future needs, such rear projection, require it.

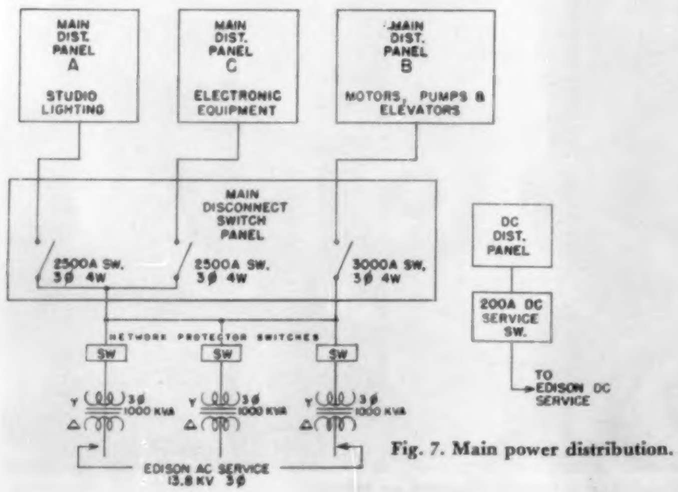

Fig. 7. Main power distribution.

Fire Protection

The fire protection systems in a building of this kind are extremely interesting. The Telecentre has five separate fire alarm systems. First, there are the conventional local manual fire boxes located at strategic places on every floor. On these a lever is pulled which rings fire gongs throughout the building. These are coded to indicate the location of the fire.

The second system is a sprinkler system of the usual type in which a fusable link keeps the sprinkler head closed. When high temperature in any area melts this link, a heavy spray of water is emitted. The system is under pressure at all times and is doubly protected in that it may be supplied by either city water or a gravity tank on the roof of the building. This system is known as a supervised system. Once a sprinkler head goes off the pressure in the stand pipes will drop, and this in turn sends an alarm signal to the American District Telegraph Co. Trouble signals are also transmitted in the event of low pressure, low water in the tank, or an inadvertently closed valve.

The third system is a manual system which parallels the local fire boxes. When the glass is broken an alarm is transmitted to the American District Telegraph Co.

The fourth system is known as a rate-of-rise system and consists of thin copper tubing that is run around the molding of every room. This tubing contains air at atmospheric pressure, and is connected to diaphragms with a slow leak. If the temperature in any particular room increased rapidly the pressure differential transmits an alarm signal both locally and to a central station. However, normal slow changes in atmospheric pressure do not cause an alarm.

The fifth system is used in Master Control only, where there is a great deal of electronic equipment. In the event of fire, sprinklers could do untold damage to equipment, and cause short circuits of a very severe nature. CO_2 is used in lieu of water. The system is designed to fill the entire Master Control area with carbon dioxide thirty seconds after an alarm signal warns personnel to vacate the area. The tanks of CO_2 are located in the basement.

These five systems are supplemented by conventional stand pipes with hose and hand extinguishers.

Control Rooms

Another interesting architectural feature is the split control booth. A diagram (Fig. 8) shows that the functions of audio, video, and video switching are separated. The section in the front contains the program director and the switcher only. In front of them are camera monitors, preview monitors and line monitors. Directly in back of the switcher is a separate booth containing the audio operator. To the left of the audio operator is the video control section. These spaces are connected by doors which are normally kept closed. Glass windows permit the audio operator to see the video control room on his left, and the monitors in the director's room in front of him. He also has an excellent view of the acting area. The director, of course, has a full view of the acting area and all monitors.

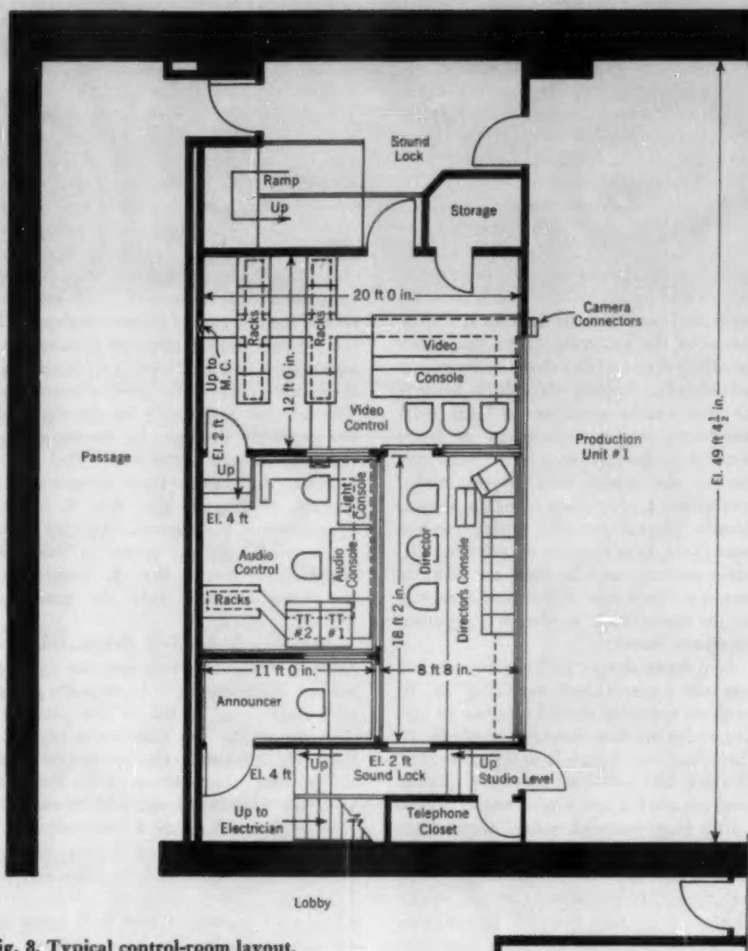

Fig. 8. Typical control-room layout.

This arrangement has proven to be extremely satisfactory. The production staff, as well as the technicians have found that this separation has permitted smoother, more trouble-free operation. In the event of camera trouble, the director does not hear instructions passed from video control to camera. Likewise,

Fig. 9. Typical control room; video control at the rear in this view, audio at left.

the director does not hear conversations between studio control and master control, checking levels or line difficulties. The audio man can set his speaker volume as high as necessary for proper monitoring without disturbing other members of the team. The director and the switcher have audio monitoring facilities that can be adjusted to suit their needs and they can work in a relatively undisturbed atmosphere (Fig. 9).

During a program there are both video sources and audio sources which must be integrated and fed to the local transmitter to the network, or to the video recording room, either simultaneously or individually. Among the video sources are live studio cameras, a local field program, a network program, or feeds from the projection room in the building. Among the audio sources are studio microphones, recordings from the studio, records played in the studio control room; and, as in the case of video signals, audio sources may be from the field or from a network line. Other audio sources are the soundtrack on film or a separate announce booth.

As a basic design philosophy, we feel that the control and switching of all program material should be done in one spot under the direction of one individual. Therefore, our system is designed so that all video and audio sources for a specific program are fed to a single control booth.

In a large network center of this kind we find that in many cases custom equipment is necessary to provide the capacity and flexibility required. Certain equipment units specially designed by our engineering department for the Telecentre will be described.

Perhaps the heart of the studio technical facilities, at least to the program department and client, are the audio and video switching and mixing units. This is the part of the telecasting system where nontechnical personnel and home viewers may judge the results.

Video Mixing

The complexity of a video mixer is primarily a function of the special effects to be accomplished and auxiliary services to be performed. Inasmuch as these are not primarily a function of the size of the studio, identical switching facilities, both audio and video, have been furnished to all studios regardless of size.

The design procedure was somewhat unusual. The front panel of the switcher was the first section of the switching system to be planned. Several experimental layouts were tried and a full-scale mock-up was built. When the design appeared to satisfy most of the requirements, it was then turned over to the circuit group.

This video system consists of an operating panel, mixing amplifier and power supplies. Figure 10 shows the front of the panel. At the bottom is a row of buttons for switching between sources, called Bus A. Above this is Bus B, a row of potentiometers for manually mixing any or all of the sources. The row of pilot lights directly above the individual gain controls indicate when any channel is not completely disconnected. Just to the left of center are a pushbutton, a selector switch, and toggle switch aligned vertically. Actuating the pushbutton transfers the output from any individual source to Bus B, the manually controlled potentiometers. The selector switch sets the rate of picture change and the toggle setting determines whether the signal goes to black level, i.e., fades; or does not reduce to zero, i.e., laps. The selector and toggle on the right of the panel act similarly for the switching between sources on Bus A. The lever faders to the extreme right allow manual control of Bus A and Bus B levels. When locked together the operator may go manually at any speed or variable speeds from Bus to Bus. By separating the levers he may mix the Buses as desired.

Switcher, position 1, designated Remote 1, essentially bypasses the mixing system. A standard 1.4-v composite video and sync signal is fed to this position. The button on the switcher actuates a relay which transfers the line output from the normal mixer output to the Remote 1 signal. Positions designated Remote 2, Remote 3 and Remote 4 feed individual tubes on both the A and B buses with a standard 1-v noncomposite video signal. Likewise, the positions designated Cameras 1 through 6 feed both buses in the same manner. The bus-to-bus switch picks up any signals appearing on Bus B, the effects Bus. After final selection of signal, blanking is added. All sources are operated at zero setup to facilitate mixing and special effects, and the setup of the final outgoing signal is determined when blanking is added. Finally, sync is added to complete the standard signal. Figure 11 is a simplified block schematic.

The switching operation, which takes place in the studio control room, in reality controls the bias of a tube located in master control. The switching rates selected are determined by the time constant of an RC network. The mixing operation of Bus B, controlled by the potentiometers, varies the bias to obtain different signal levels.

Audio Mixing

As was the case with video, the audio operational requirements were translated into numbers of controls, amplifiers, and their relative functional importance. Finally, a panel layout which represented reasonable system design with a compact mechanical arrangement was drawn up, and the assigned engineers worked out the circuitry behind the knobs and levers.

The major operational requirements were:

(1) Twelve studio microphone positions;

(2) An announce circuit, primarily for use in an announce booth separated from the studio, but also available from the studio floor.

(3) Built-in sound effect equipments, including variable peaked telephone filter, a bandpass filter, and a tape reverberation and echo effects unit.

(4) Four remote audio sources under separate attenuator controls.

(5) Applause control, which in large studios or theaters becomes a real problem. In this unit applause level control is placed in a relatively important functional position in the mechanical layout.

(6) Coordinated control of video with audio, which permits the technical director doing the video switching to control, through his video switching buttons, sound sources which may be patched to the studio.

(7) Public address system control. This is a must in a large studio or theatre and, like the applause, its volume control is in a relatively important mechanical position on these consoles. Further, the public address system should be provided with a selector or multiple selectors which permit an operator to bridge only one microphone at a time.

(8) A playback system, separate from the public address system. This provides audio cue to the studio while film or remotes are occupying program time. This is not to be confused with the normal intercom circuit between booth and studio.

(9) Turntables equipped with a mercury-type starting switch, lever action fader control, cuing amplifier and speaker, and triple pickup heads. This makes the turntables an independent unit so that any type of record can be "cued-up" and "snubbed" ready for operation. When releasing the record one hand can hold the record, turn on the driving motor, and fade in the recording all in one coordinated motion.

A second sound effects system and switch are provided so that the sub-buses can be modified by the insertion of a reverberation unit and low end roll-off filter. The Audio Devices Tape Reverberation Units not only provide a live effect for music, which frequently is "dead" in a TV studio, but also provide the usual echo effects sometimes required for drama, commercials, etc.

Figure 12 shows the panel layout which, by the use of lever action faders, permits a compact and efficient functional design to provide the audio controls outlined in the preceding summary.

The twelve microphone faders are divided in two sections with transfer switches to Bus A or Bus B immediately below the levers.

The Bus A and B faders are offset downward to give a better "feel" to the control panel. The submaster for the

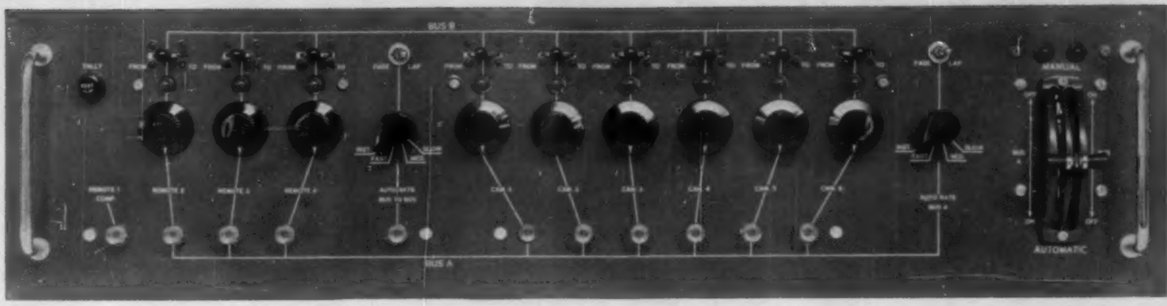

Fig. 10. Panel of video switcher.

studio microphone circuits is the left of the center group of three. This submaster, which is the overall control of the studio microphones, is closely grouped with the public-address control and the applause control. Coupled with the shape of the knobs on the faders a single hand, or in fact three fingers, can control these critical levels which, incidentally, need controlling for a large portion of the time during most of the more ambitious types of programming. The inevitable cry from the program department for more applause, louder PA and more and better level from the star of the show can be satisfied with a minimum of physical effort on the part of the operator.

The lever faders controlling the master volume control and announce fader are toward the center in the upper left group of five. Perspective and reverberation controls are located at the extreme left, and the "Remote 1" control is also located in this group.

The switch over the Remote 1 fader is a relay energizing control. When operated to the left it directly operates the relay and the audio is completely under control of the audio operator. When operated to the right the relay picks up an energizing signal from the composite video button of the video switcher.

Remotes 2, 3 and 4, and the turntable faders are grouped to the right of the VU meter.

There are two key switches over each of the three right hand remote faders. This permits an audio operator's local control of two sources for each fader, or

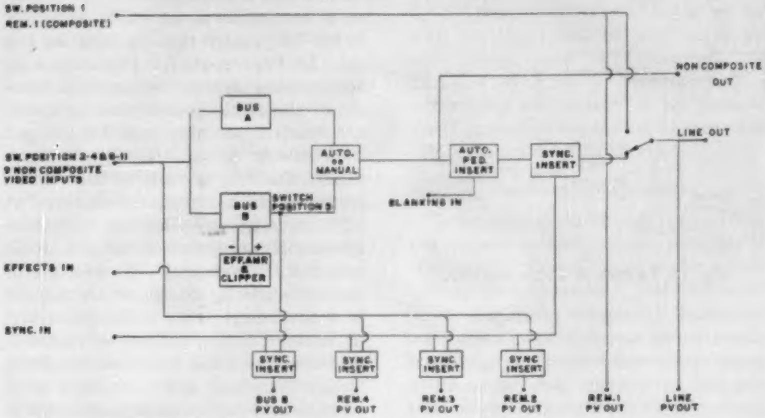

Fig. 11. Block schematic of video mixing system.

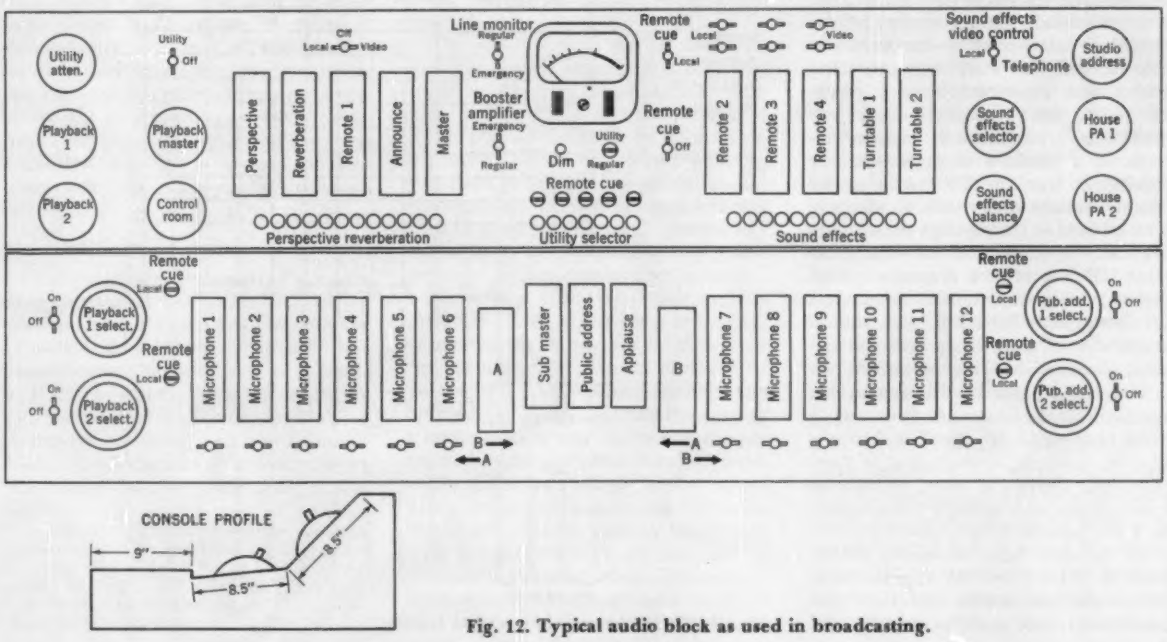

Fig. 12. Typical audio block as used in broadcasting.

an automatic control of either of two sources from the video switching position. These positions are provided with two audio sources, since any one video switch controlling a camera may have two multiplexed projectors and, therefore, two associated audio sources.

Video Patching

Another interesting item at the Telecentre is the system of patching used for video and sync signals. The usual type of audio circuit (Fig. 13) has microphones

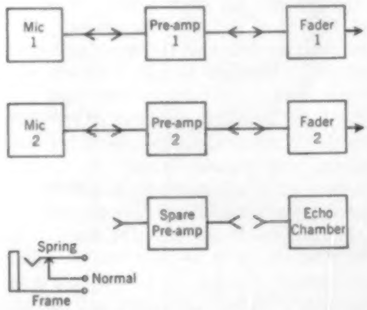

Fig. 13. Layout of audio console.

normalled through preamplifiers to faders. In the lower lefthand corner is a detail of the well-known arrangement of contacts on a single jack. In an emergency, a spare preamplifier may be substituted instantly by means of two patch cords. For operational reasons it may be desired to have microphone #1 appear on fader #2; a single patch can accomplish this readily. The major advantages of such a system are (1) operational flexibility and (2) instant availability of spare equipment and circuits.

A video system, based on equipment having single-ended outputs and using coaxial cable instead of shielded pair for interconnection, cannot easily be arranged for this type of system operation. The use of an audio-type patching system was considered, then a mock-up panel was constructed and tests made for crosstalk and capacity effects. As a result of these tests it was concluded that a TV plant could operate satisfactorily with a patching system based on the use of jacks and plugs originally developed for audio applications. The use of such a system offered the previously mentioned advantages of operational flexibility and instant availability of spare equipment and circuits, plus substantial cost reduction.

The components of this system are standard items: an A2A jack and a PL55 plug which are wired as shown in Fig. 14. Note the arrangement of three jacks, one above the other, to form an input, output and multiple combination. In a few instants extra contacts are provided for tally light circuits in Master Control. At the Telecentre approximately 3500 video connections and 1000 sync connections were made in this manner. In a TV plant of this size we have estimated a cost saving of $45,000.

Intercommunications

The need for a flexible intercom system is paramount in TV work. After discussion of several types of systems, it was decided to adopt a simplified crossbar system (Fig. 15) following Bell Telephone Company practice.

There are five basic circuits that form a part of this system. What is called the "A" circuit carries noninterrupted program cue, the order circuit, and the microphone circuit for return talk. The "B" circuit, which appears on a separate set of receptacles in the studio, is similar to the "A" except that the program cue may be interrupted for instructions by the technical director, the program director or the audio control man. A standard headset assembly may be plugged into either "A" or "B" circuit receptacles. The "C" circuit is the carbon system associated with the cameras. A "D" circuit, while not an individual system, is an extension of the audio operator's, technical director's, or director's source circuit which appears in a patch field in the transmission bays at Master Control, and can be routed as required to external locations. Similarly, remote incoming order circuits can be patched into the intercom loudspeaker in the director's booth of any studio. The "E" circuit is the studio address system, which is normally used during rehearsal for instructions to the cast and floor personnel. The public address system for audience coverage and the playback system for film and turntable sound in the studio are separate from the intercom and are not shown.

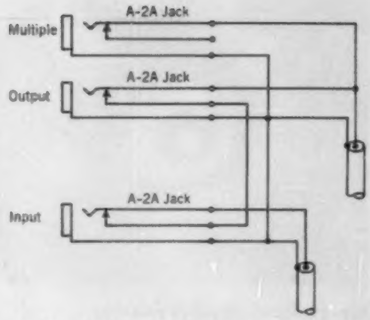

Fig. 14. Typical wiring of video jacks.

The building blocks that make up this system are essentially sources and loads. The sources are microphones, preamplifiers, keys or relays for selecting the desired load or loads. The loads are bridging amplifiers feeding either loudspeakers or the standard intercom headset assembly used by floor personnel.

Acknowledgment

The author wishes to credit a few of those who worked tirelessly to make this project possible. The architect was William Meyer. The construction was spearheaded by Charles Dalton of the John Lowry Company. The electrical work was under the supervision of Zoltan Hartman of Belmont Electric Co. The members of the Du Mont network General Engineering Department under the supervision of Bob Bigwood, assisted with every phase of the construction, beginning with the basic planning, and continued through the completion of the complex operation. Much of the electronic equipment was designed and built by members of our Department.

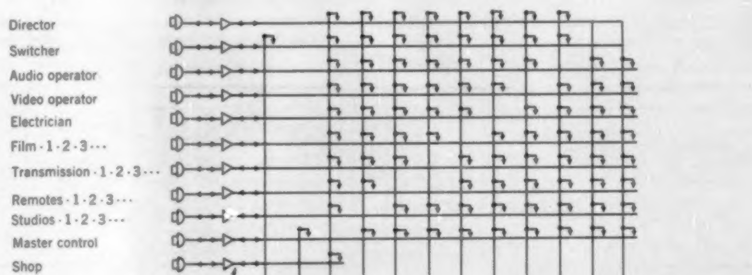

Fig. 15. Block schematic of intercom system.

An Inquiry Into Standards for Television Slide Production

By RICHARD H. HILL

This paper deals with the problem of establishing a method for the commercial production of slides which will give good and reliable reproduction on TV chains aligned to an accepted and recognized standard, such as the SMPTE Test Film. It describes the production method developed by a Canadian firm, Williams & Hill, Ltd., based on a series of experimental tests made with the cooperation of the Canadian Broadcasting Corp. The tests were carried out on chains aligned to the SMPTE Test Film, and the slides used were specially produced for the purpose.

Five separate but related goals were aimed at in the development of the method of commercial production of television slides described in this paper:

(1) Correlation with an established TV standard;
(2) Matching quality between slides;
(3) Reproduction of a good TV picture;
(4) Creative freedom and control; and
(5) Predictable reproduction.

To achieve these goals it was deemed necessary to carry out every stage of production from layout to finished slide within one organization. Much confusion concerning the production of TV slides has been due to inconsistency of approach. By directly controlling the material submitted for telecast, it was found that indirect control could be exercised over the remaining stage of telecast. This indirect control, however, could not be achieved without a thorough knowledge of the television system.

A good TV slide begins with the artist who designs and prepares the graphic from which it is made. The photographer must transfer the picture onto the slide in such a way that the conception of the artist will be telecast as predicted. Both artist and photographer must be able to visualize the picture in terms of the television waveform and its resulting pictorial values.

Behavior of the TV System

The image produced on the TV screen is adjusted until it conforms as closely as possible to an ideal picture. The criterion of judgment is based on the television waveform. It describes a picture in terms of electrical signal, which varies in voltage according to the tones it represents — maximum for white, and minimum for black. The waveform is represented on the monitor by the superimposition of a mass of lines, each representing a cross section of the picture.

The perfect waveform may be described as a signal which varies to the fullest extent within its prescribed limits without allowing the values it represents to become distorted. In other words, every TV picture should carry the fullest undistorted range of tones possible, and these tones should extend from black to white. If a picture does not possess these characteristics, adjustments are usually made favoring a full waveform extending from black to white at the expense of distorting the tonal values of the original picture.

The adjustments made by the television system create a set of variables which must be overcome if an indirect control is to be exercised over telecast through the nature of the material submitted. To achieve this the material should require:

(a) that adjustment required by the TV system be a minimum; and

(b) that any adjustment made should be predictable.

The controls exercised by the video operator consist mainly of raising and lowering the general level of the waveform and stretching and compressing it. Under telecast conditions the video operator usually has no opportunity of seeing the slide which is responsible for the waveform on his monitor, and will proceed to make "corrections" without any reference to the original picture. The values of the picture can quite "correctly" be distorted beyond recognition, and the intended effect of the slide completely destroyed. This should not be blamed on the video operator, but on the material he receives. The situation becomes not only unpredictable, but also impractical if he attempts to vary his reaction according to the supposed effect of each picture.

The TV chain itself also makes adjustments according to the nature of the material it receives. With many TV systems all the monitors are clamped to establish a reference black. This feature is not as common amongst home receivers as it is amongst station monitors. If the video operator adjusts according to the clamped waveform and picture on his station monitor, he is not necessarily making correct adjustments for producing the best picture as seen on the majority of home receivers. When a picture is "over-contrasty" other distortions occur. The signal amplitude produced is too big for the prescribed limits in the waveform with the result that the extreme upper and lower parts are "crushed" or chopped off. Further distortions occur when slides are too dark or too light. In many cases it is impossible to correct or compensate for these distortions.

Suitable Density Characteristics

By producing slides with certain density characteristics, it is possible to eliminate or forestall most of the adjustments and distortions just discussed. Tests were made to establish the overall tonal content of a slide which gave the best TV reproduction without any operational adjustment on chains that had been aligned to the SMPTE Test Film. A slide with a mean density of about 0.6, beginning near 0 for white, produced the most nearly perfect response. Recognizing these characteristics, it is possible to produce slides of wide picture variety which automatically give an excellent television waveform on equipment aligned to a recognized standard, although subjects in excessively high or low key are excluded.

It was established that the general level of the waveform was largely governed by the mean density of the slide from which it originated. Mean density readings were made by an instrument containing an electric eye which produces a reading by reacting to the total amount of light passing through the transmitted area of the slide (Fig. 1). The drawing (Fig. 2) shows an arrangement of the instruments components. The densitometer is calibrated by switching on the light and placing the unloaded slide carrier into position and adjusting the meter to read at zero. The slide carrier shields the picture area which does not appear on the TV screen.

Figures 3, 4 and 5 illustrate three different waveforms produced from slides of different mean densities printed from the same negative from which the picture (Fig. 6) was printed. The mean densities of the slides producing the waveforms A, B and C are 1.2, 0.28 and 0.58, respectively. The waveforms were produced on an iconoscope chain aligned to the SMPTE test film without additional

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Fig. 1. Densitometer designed for taking mean density readings from TV slides. The slide carrier can be seen protruding from the side of the instrument, while the knob for calibrating readings is situated under the man's hand.

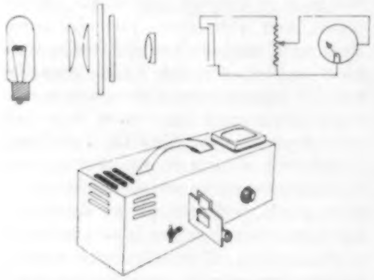

Fig. 2. The instrument and its components: light, condenser, slide carrier, lens, electric eye, circuit and meter.

adjustments being made by the video operator.

Serious distortions occur in waveforms A and B resulting in unbalanced signals. Waveform A shows compression from black level and waveform B compression from white level, producing a distortion of tonal separation which cannot be properly corrected by the video operator. It is of interest to note that white in both slides originating waveforms A and B was represented by a density of 0.0. This clearly illustrates an instance of the influence of the general tonal composition of a picture on the reproduction of a specific tone. Waveforms produced from the same slides on a vidicon chain showed distortions but of a different nature. In the waveforms corresponding to A, compression occured at black level; and in the waveform corresponding to B, compression occurred at white level. In both cases permanent distortion of tonal separation occurred in areas of compression.

In contrast there are no noticeable distortions in waveform C. The signal is fully extended and the body of the waveform nicely placed, giving good separation between each tone represented on the slide. Figures 7 and 8 illustrate another slide with a mean density of 0.58. Although the picture is very different from that of Fig. 6, it is not difficult to notice the similarity of its waveform to the waveforms shown in Figs. 3–5. It was also produced on the chain aligned to the SMPTE test film without further adjustment. Similar waveforms from both these slides were produced under the same conditions on a vidicon chain.

The tonal quality of a picture is best preserved by using as wide a contrast ratio as possible. This gives the greatest separation between each step of the tonal scale and permits the minimum distortion in producing a full waveform. In theory the television system can handle a contrast ratio of 40 to 1. However, 20 to 1, or even less, appears to be characteristic of most of the material received by TV stations, and 30 to 1 is widely accepted as the optimum contrast ratio for telecast.

Unless the lightest tone in a slide is represented by an extremely low density, it is almost impossible to produce a variety of material suitable for television with a contrast ratio as high as 40 to 1. This is because the contrast ratio must be achieved by extending it well into the darker side of the tonal scale, with the result that the mean density of the slide becomes too high. Much of the material received for telecast has a contrast ratio of about 20 to 1 (30 to 1 optimum). This is because of the difficulties in producing, with good tonal values, extremely low densities on film.

The problem of producing a slide with high contrast ratio and a mean density of about 0.6 was overcome by printing directly onto glass from a combination of two negatives. The artwork was prepared in two sections, one of which was mounted over the other in the form of an

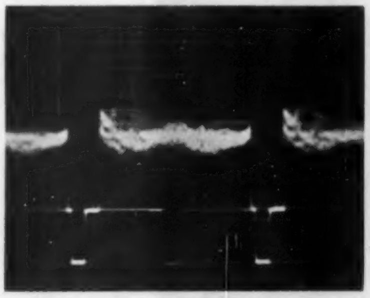

Fig. 3. Waveform A (density 1.2).

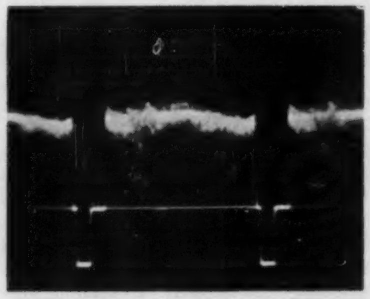

Fig. 4. Waveform B (density 0.28).

Fig. 5. Waveform C (density 0.58).

Fig. 6. Image on slides, printed at different densities from common negative, from which waveforms A, B and C originated. Mean densities were 1.2, 0.28 and 0.58, respectively.

Fig. 7. Image from which waveform D originated. The mean density of the slide was 5.8.

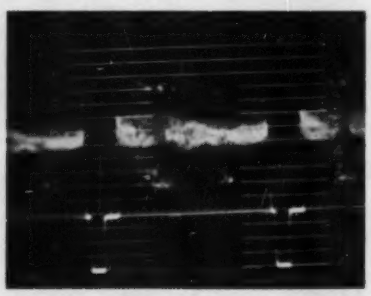

Fig. 8. Waveform D.

overlay to register. A set of alignment crosses on the card to which the artwork was mounted gave a common registration for both sections. The section mounted directly onto the card carried all the tones in the picture other than absolute white. This was photographed with a tone negative. A line negative was made of the overlay section which represented the absolute white in black. This negative was processed and retouched to opaque all areas other than those representing absolute white. A contact print on film was made of this negative, and positioned onto the tone negative so that the emulsions faced each other and the alignment crosses were in register. This double negative was then placed in an enlarger for reduction printing onto glass (Fig. 9).

This technique made it possible to achieve a density of near zero for absolute whites without distorting any other tones in the picture. Considerable contrast ratio could be achieved without even approaching a density of 2.0 for the darkest tone, and a very definite reference for white was established in the waveform.

The density of the darkest tone in a slide is not as critical as the lightest. Good waveform references for black can be obtained from slides in which the darkest tone is as low as 1.35, as long as there is a density of near 0.0. Clean separation between tones is difficult to achieve when they are represented by densities above 1.6. This does not mean that the darkest tone in a slide should always be kept below 1.6.

By summarizing the results of the research and experiments just described, it was possible to formulate a set of density characteristics describing a slide which will give good and reliable television reproduction.

Production Approach

It was necessary to relate the principles just described to a commercial system of graphic arts production which would permit the greatest possible creative control and freedom. This was sought by standardization in almost every direction except the creative execution of the graphic form which the slide originated. Consideration of the technical requirements of each picture was left in the hands of the artist, who exercised his judgment and knowledge to realize his conception on the TV screen.

Figure 10 is an outline of the main stages in the system of production that was established. The first basic step lies in the conception of the picture represented by the design. Here the elements of the picture are organized into a composition suitable for reproduction on the TV screen, and a broad approach for execution established. This initial creative planning is necessary, as television demands that the technical and artistic characteristics of a picture be regarded as a whole.

The next step involves a more detailed working out of the conception by translating it onto the master layout. Here the first indication of standardization becomes evident. All finished art is made to the one size, as indicated on the master layout sheet which also shows the "essential area" of the picture within which all its elements requiring best reproduction are to be composed. A standard size of 6 × 8 in. was chosen for the picture area. This standardization serves a number of purposes:

(1) The artist becomes accustomed to the one size, and can more readily assess the characteristics of the picture as a whole, enabling him to make calculations based upon comparison with past experiences.

(2) The size is not sufficiently large to invite the artist to load any area with more detail than it should carry for good television reproduction.

(3) A size of 6 × 8 in. allows the direct use of most type styles and is well suited for the case of standard 8 × 10 in. paper prints.

(4) When the artwork is placed on the copy stand for making the slide negative, its standardized size established fixed positions for the camera and lights.

The master layout provides the reference of scale for all the other elements to be assembled into the finished art. The assembly aspect of graphics for TV slides is important as it allows a great variety of techniques and materials which can be considered in their own right as elements

Fig. 9. Enlarger adapted for printing slides from 4 × 5 in. negatives, permitting use of double negatives and printing onto glass stock.

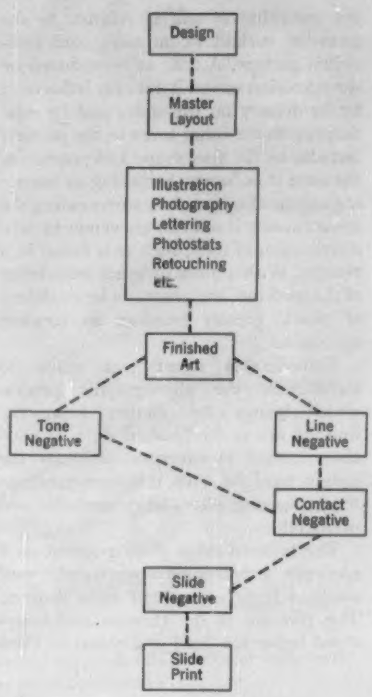

Fig. 10. Main stages of production for TV slides established by Williams & Hill, Ltd.

contributing toward the overall result. Here familiarity with the photographic reproduction onto slides of the various materials used is important. The finished art is almost without exception executed in monotone, allowing better judgment for tonal comparisons. The paints used are standardized, and several paper prints of the one photograph are usually available so that the one with the most suitable tonal characteristics can be selected.

Each picture for a TV slide should be executed with the medium's technical, requirements very definitely in mind. The artist should be conscious that in each slide a reference for black and white is necessary to protect the other tones in the picture. He should also know how these references can best be achieved. Typesetting in black on acetate provides an excellent and consistent reference for black, while an absolute white can be achieved by use of the overlay technique for double negatives. The problem of maintaining an approximate mean density can be overcome by a number of subtle approaches, such as the use of acetate to darken almost unnoticeably certain areas of the picture, or the concentration or dispersal of tone to create the illusion of brightness or dullness throughout the picture.

Although generalizations provide a valuable guide to the preparation of TV slides, they should not be looked upon as a rigid set of rules. The exact behavior of

the television system is relative to the countless variables composing each individual picture. A tone as reproduced on the television screen is not only influenced by its density on the slide, and its relationship to the other tones in the picture, but also by the size, shape and position of the area it occupies. Streaking or smearing can be eliminated by surrounding the areas causing it with an uneven or broken distribution of tone, such as is found in a texture. With a more intimate knowledge of the medium, the artist can be confident of much greater freedom in creative approach.

Considerable effort was made to standardize the photographic process which brings the picture from the finished art to the finished slide. If variable control is exercised through the judgment of the artist, it is important that the remaining stages be dependable and predictable.

The finished art is photographed on a specially constructed copystand, well shielded from extraneous light sources. The position of the camera and copystand lights are fixed and constant. Care is taken to insure that the mixing, timing and temperature of the processing solutions are constant. After the master negative is completed, reduction prints are made on the emulsion coated glass, through an enlarger specially adapted for the purpose. The light source in the enlarger is stabilized by means of an equalizer, and exposures made by an electronic timer set to fractions of a second. Several test prints are made for checking on the mean densitometer. This is necessary owing to certain unavoidable variables, such as the differences between batches of photographic stock. With the correct exposure established, final slide prints are made. Each stage of the processing is carefully timed to an established standard. The slides are washed, dried, mounted and finally checked again on the mean densitometer before shipment. Throughout the whole photographic process a gamma of approximately 1 is maintained.

Conclusion

An independent test was carried out at CFRN-TV, Edmonton, under the direction of Harold Wright of the Canadian Broadcasting Corp. Slides were selected at random from the station files to form a batch of 25 to 30, all of mixed origin. They were loaded into a slide projector without discrimination and projected in sequence through a vidicon chain aligned to the SMPTE test film, without further adjustment by the video operator. The waveforms produced varied from $\frac{1}{2}$ to $1\frac{1}{2}$ volts. The correct voltage for the waveform is one volt. Sixteen slides produced by the system described in this paper were then selected at random from the files by the station staff and loaded indiscriminately into the projector. The waveforms produced under the same conditions as the previous test showed a constant black level and a variation in gain not more than 5%. Under practical operational conditions there is usually no opportunity for adjustments to be made between slides by the video operator. The slides used in the second test belonged to at least eight different commercials, and were produced over a period of about a year and a half

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Some Considerations Concerning the Gamma of a Tricolor Picture Tube

By WILFRID F. NIKLAS

The expression for "gamma" of tricolor picture tubes is derived and analyzed for its correlations with the various gun design parameters. The two methods of compensation for the different RBG-phosphor efficiencies (utilizing unequal drives and equal cutoff voltages for the triple gun or employing equal drives and unequal cutoff voltages) are discussed. The influence of manufacturing tolerances on gamma and the necessary gamma equalization are described. Gun designs are discussed which facilitate the utilization of equal drives on all three guns. The conclusion is derived that a gun triplet with different spacings in the triode may present a realistic solution.

The performance of a picture tube, particularly a tricolor picture tube, is governed by the luminance response to the incoming video signal. This response determines the contrast in the picture and in the case of a tricolor tube also the undistorted color reproduction.

The obtained luminance on the face of a tube is, over a wide range, proportional to the energy of the electrons dissipated into the phosphor layer. At constant screen voltage the energy of the electron beams is approximately proportional to the screen current I_s. We can write, therefore:

$$B = K_1 I_s \qquad (1)$$

where

B = luminance,
I_s = screen current,
K_1 = energy efficiency of the phosphor (at constant screen voltage).

In the case of a tricolor tube, Eq. (1) has to be replaced by three equations for the three guns combined with the three color phosphors. The following discussion will be restricted to one of these combinations unless it is otherwise indicated.

Figure 1 shows typical luminance curves for the RBG phosphors. The resulting luminance is influenced by the phosphor, the thickness and quality of the aluminum layer, the screening and aluminizing process, etc. The measurements of the luminance are generally not very reliable (e.g., phosphor saturation causes the luminance to drop for optimum focus). It is, therefore, preferable to use the screen current as indication for the response of the picture tube to the video signal. We can write for I_s:

$$I_s = \text{prop. } E_D{}^{\Gamma_s} \qquad (2)$$

where

E_D = grid drive (from visual cutoff, in volts),
Γ_s = "gamma"; the index s indicates that gamma is associated with the screen current.

Γ_s is given by:* $\Gamma_s = \ln I_s / \ln E_D \qquad (3)$

A contribution submitted on November 8, 1955, by Wilfrid F. Niklas, then at CBS Laboratories in New York, now at The Rauland Corp., 4245 N. Knox Ave., Chicago 41.
(Revised paper received on June 13, 1956.)

*The customary definition of gamma in photography is given by:[1]

$$\Gamma_s = \partial \ln I_s / \partial \ln E_D$$

This definition gives the slope of the curve ln I_s vs. ln E_D in every point while Eq. (3) gives the slope of the curve over growing intervals of E_D with a fixed lower boundary (E_D = 0). It is felt that Eq. (3) is better suited for the further discussion. This equation is also generally used for the determination of gamma of cathode-ray tubes.

The purpose of this paper is to derive the correlations between gamma, as defined by Eq. (3), and the various tube parameters. After establishing this theoretical basis, we shall describe the two methods of compensation for the different RBG-phosphor efficiencies:

(a) using unequal drives and equal gammas;
(b) employing equal drives and unequal cutoff voltages.

Further, the influences of various gun tolerances on gamma will be discussed. Finally, operating modes and gun designs will be described which facilitate the generally preferred method (b).

1. Gamma Expressed by Tube Parameters

The screen current in a shadow mask tube can be expressed by:

$$I_s = \eta_M I_M \qquad (4)$$

where

I_M = electron current leaving the gun (amps),
η_M = constant (electron) transmission of the shadow mask.

I_M is associated with the cathode current I_K as follows:

$$I_M = \eta I_K \qquad (5)$$

where

η = gun efficiency (electron transmission of the gun being a function of gun parameters),
I_K = cathode current (in amps).

According to a semiempirical formula by Moss,[2] I_K as a function of E_D is given by:

$$I_K = K_2 E_D^{3.5} E_c^{-2} \qquad (6)$$

where

E_c = (absolute value of) grid 1-voltage for visual cutoff,
K_2 = term describing the cathode quality (amps/volt$^{1.5}$).

If the cathode surface is in a normal state of activation and the cathode works under space charge limited conditions, Moss gives for K_2 (see Sec. 5.2):

$$K_2 = 3\cdot10^{-6}\ \text{amps/volt}^{1.5} \qquad (7)$$

A plot of Eq. (6) with $K_2 = 3\cdot10^{-6}$ (parameter E_c) is shown in Fig. 2. It can be seen in this figure that in a practical case the experimentally determined cutoff voltage may be shifted in the positive direction (to the right in the graph) with respect to the actual value. Accordingly, a larger gamma will result. Combining Eqs. (4), (5) and (6) leads to an expression for the screen current as a function of the grid drive:

$$I_s = \eta\eta_M K_2 E_D^{3.5} E_c^{-2} \qquad (8)$$

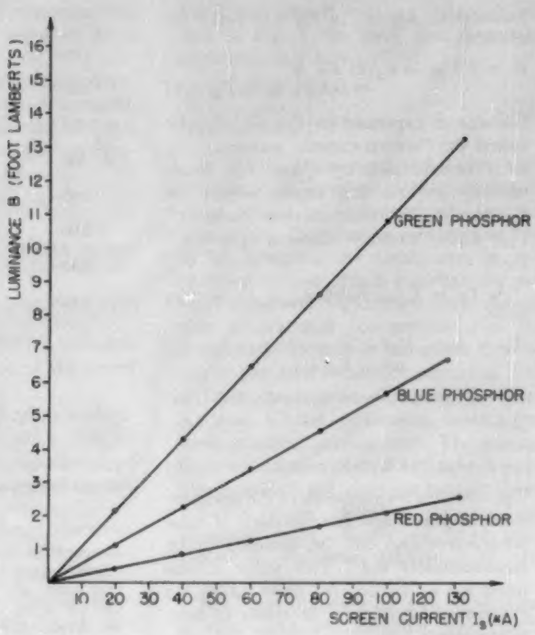

Fig. 1: $B = K_1 I_s$. Measured on 21-in. RCA tricolor tube with 27-kv screen potential; aluminized screen.

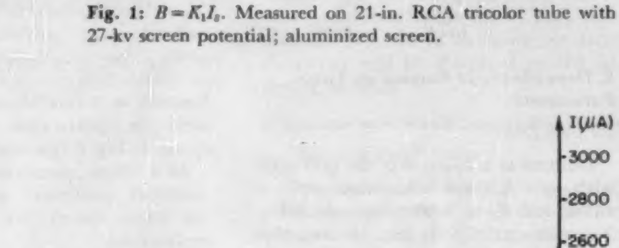

Fig. 2: $I_K = F(E_{g1})$. Theoretical curves according to:
$$I_K = 3.10^{-6} E_D^{3.5} E_c^{-2}$$
with $E_D \ldots_{g1}$ drive (from visual cutoff) (volts),
$E_c \ldots$ (visual) cutoff voltage (volts),
$I_K \ldots$ cathode current (in μa).
Broken line: Experimental curves for $E_c = 50$ v. The form of the curve indicates that the actual cutoff voltage must be larger than 50 v.

Substituting Eq. (8) in Eq. (3) yields for gamma:

$$\Gamma_s = 3.5 + \ln \eta_M/\ln E_D + \ln(\eta K_2 E_c^{-2})/\ln E_D \quad (9)$$

Gamma as expressed by Eq. (9) may be called the "screen current gamma," Γ_s, as it is expressed by I_s and E_D. Analogously gamma can be expressed by I_M and I_K. ("Mask current gamma," Γ_M, and "cathode current gamma," Γ_K.)

As $I_M = I_s/\eta_M$ (with $\eta_M < 1$), we can write:

$$I_M = \text{prop. } E_D^{\Gamma_M} = \text{prop. } I_s/\eta_M = \text{prop. } E_D^{\Gamma_s}/\eta_M$$

$$\Gamma_M = \Gamma_s - \ln \eta_M/\ln E_D \quad (9a)$$

and

$$\Gamma_K = \Gamma_M - \ln \eta/\ln E_D \quad (9b)$$

The electron transmission of the aperture mask is practically independent of tube parameters and can be assumed to be approximately 0.2.* This value substituted for η_M in Eq. (9) gives finally an expression for gamma in terms of tube parameters:

$$\Gamma \equiv \Gamma_s = 3.5 - 1.7/\ln E_D + \ln(K_2\eta E_c^{-2})/\ln E_D \quad (10)$$

2. Dependency of Gamma on Tube Parameters

2.1 Grid Drive

Gamma as a function of the grid drive with $\eta_M = 0.2$, $\eta = 0.8$ (*average* empirical value) and $K_2 = 3 \cdot 10^{-6}$ is shown in Fig. 3 (parameter E_c). It can be seen that gamma increases approximately in proportion to the grid drive over a relatively wide range of the drive. Note that $\eta_M = f(E_D)$, as pointed out later. A second order correction has, therefore, to be added to the curves of Fig. 3.

2.2 Cutoff Voltage

From Eq. (10) follows:

$$\partial\Gamma/\partial E_c = -2/(E_c \ln E_D) \quad (11)$$

For small changes of Γ, $\Delta\Gamma$, we obtain:

$$\Delta\Gamma = -(2/\ln E_D)(\Delta E_c/E_c) \quad (11a)$$

Equations (11) and (11a) indicate that gamma decreases with increasing cutoff for constant drive values.

Figure 4 shows gamma as a function of the cutoff voltage with the constants of Fig. 3 (parameter E_D).

2.3 Second Grid Voltage E_2

The cutoff voltage and the second grid voltage of a CRT-gun of a conventional design are related as follows:

$$E_c = P \cdot E_2 \quad (12)$$

where P is the penetration factor for the triode part of the gun ($P < 1$). Equation (12) with the penetration factor 36% is plotted in Fig. 5. Using Eq. (12) in Eq. (11), we obtain with $\partial E_c/\partial E_2 = P$:

$$\partial\Gamma/\partial E_2 = -2/(E_2 \ln E_D) \quad (13)$$

and

$$\Delta\Gamma = -(2/\ln E_D)(\Delta E_2/E_2) \quad (13a)$$

Gamma as a function of E_2 for a gun with the penetration factor 36% is shown in Fig. 6 (parameter E_D).

In a "high penetration gun" (the g_3-potential penetrates appreciably into the triode space), Eq. (12) has to be replaced by:

$$E_c = P_1E_2 + P_2E_3 \quad (12a)$$

P_1 indicates the penetration of the second grid voltage and P_2 the penetration of the third grid voltage into the cathode space. In the case of a conventional gun, $(P_2 \cdot E_3)$ contributes approximately 5% to E_c at $E_3 \approx 20$ to 30 kv. This term can, therefore, be disregarded.

2.4 Manufacturing Tolerances

The penetration factor depends on the geometric dimensions as follows:[2]

$$P = K_3D_1^3/d_1d_2 \quad (14)$$

where

D_1 = diameter of the grid 1 aperture,
d_1 = distance cathode – grid 1,
d_2 = distance grid 1 – grid 2.

The constant K_3 has therefore the following dimension:

$$[K_3] = \text{length}^{-1} \quad (14a)$$

In fact, K_3 is not a constant but depends on the diameter of the second grid aperture D_2 (inches), as field plots have shown:

$$K_3 = \overline{K_3} + K_3'/D_2^{0.4} \quad (14b)$$

where

$\overline{K_4}$ = value of K_4 for "open anode guns,"
K_4' = constant.

For conventional gun designs and a first order approximation, however, the influence of the second term in Eq. (14b) is not appreciable and can be neglected.

Equations (10), (12) and (14) show that gamma is influenced by variations of D_1, d_1, and d_2.

Expressing these variations by ΔD_1, Δd_1 and Δd_2, we obtain:

$$\Delta\Gamma = -6/\ln E_D \cdot \Delta D_1/D_1 \quad (15)$$

$$\Delta\Gamma = 2/\ln E_D \cdot \Delta d_1/d_1 \quad (16)$$

$$\Delta\Gamma = 2/\ln E_D \cdot \Delta d_2/d_2 \quad (17)$$

2.5 Gun Efficiency

$\Delta\Gamma$ is related to $\Delta\eta$ by:

$$\Delta\Gamma = 1/\ln E_D \cdot \Delta\eta/\eta \quad (18)$$

We can write: $\eta = f(E_D)$ with $\partial\eta/\partial E_D < 0$. Experience has shown, however, that $|\Delta\eta/\eta| \approx 0.2$ for $0 < E_D \leqslant E_c$. Using these values in Eq. (18) gives: $|\Delta\Gamma|_{max} \approx 0.04$. Equation (18) with $\eta = f(E_D)$ represents a slight correction to the curves $\Gamma = f(E_D)$ given in Fig. 3.

We can also write $\eta = f(E_3)$. For guns with unipotential main focus lens, this function becomes a constant design term. Experience has shown that for guns with a two-electrode main lens, $\Delta E_3 \gtrless 0$ may be required for optimum focus at a constant screen voltage and changing drive. This represents a third order correction to the curves of Fig. 3. The second and third order terms partly compensate each other as they possess opposite signs. The combined influence is, therefore, smaller than 0.05.

A gun can be designed in such a way that $\eta = f(E_2^1)$ with E_2^1 denoting an additional external voltage in the range $E_c \leqslant E_2^1 \leqslant E_2$. This design can result in $\eta \approx \text{const}/\sqrt{E_2^1}$. Such a system would give high values for $|\Delta\eta/\eta|$ and could be used to produce large values for $\Delta\Gamma$ according to Eq. (18).

3. Correction for the Unequal Phosphor Efficiencies

3.1 Unequal Drives

The three phosphors of a tricolor tube have different energy efficiencies as pointed out at the beginning of this paper (Fig. 1). Using Eq. (1) and Fig. 1,

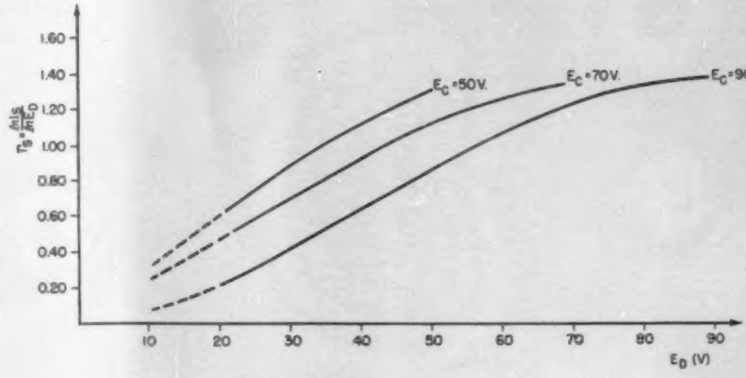

Fig. 3: $\Gamma_s = F(E_D)$. $\eta_M = 0.2$; $\eta = 0.8$; $K_2 = 3 \cdot 10^{-6}$; (I_s in μa; E_D in volts).

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* The electron transmission of the shadow mask depends on the mask design which varies slightly with the tube size as well as with the manufacturer. It should also be noted that a mask consisting of etched photoform glass shows a transmission value slightly smaller than the value for an otherwise identical metal mask. The transmission may extend, in fact, from 0.1 as lower limit to 0.2 as higher limit. However, it can be stated that $\eta_M \geq 0.15$. For convenience the value 0.2 has been assumed here.

we find the three energy efficiencies of a given example (at 27,000-v screen voltage) approximately with:

$$K_{1,R} = 2.0 \cdot 10^{-2}\ \mathrm{FL}/\mu\mathrm{a},$$
$$K_{1,B} = 6.0 \cdot 10^{-2}\ \mathrm{FL}/\mu\mathrm{a},$$
$$K_{1,G} = 11.0 \cdot 10^{-2}\ \mathrm{FL}/\mu\mathrm{a}.$$

It is generally postulated that: $B_R:B_B:B_G = 0.30:0.11:0.59$. This postulate, together with the phosphor efficiencies, results in the fact that a shadowmask tube requires *unequal* drives if an identical gamma for all three guns is assumed.

It should be noted that gamma is a function of the drive. It is therefore generally not possible to obtain a strictly monochromatic gray scale on a shadow-mask tube, provided that no accurate dynamic gamma correction is applied.

The system mentioned here has been utilized generally in color receivers. It possesses the inherent disadvantage that an unequal amount of amplification is required for the *RBG* signal. Further, the red gun is generally driven very hard (sometimes even positive), which may result in premature cathode failure.

3.2 Unequal Cut-off Voltages

In the system outlined in the previous section, the unequal efficiencies of the three color phosphors have been compensated for by using three different current values; this in turn has been achieved by three different drive values.

It is possible to obtain the required current values by using equal drives for all three guns if the transconductances of the guns are adjusted in a proper way.

It is possible to adjust the transconductances by changing the cutoff voltages. The screen current is connected with the cutoff voltage by the well-known relation (see Sec. 1, Eq. (8)):

$$I_s = \eta\eta_M K_2 \cdot E_D{}^{3.5} E_c{}^{-2}$$

The transconductance follows immediately with:

$$\partial I_s/\partial E_D = \eta\eta_M K'_2 \cdot E_D{}^{2.5} E_c{}^{-2} \qquad (19)$$

Thus, the transconductance is inversely proportional to the square of the cutoff voltage.

One will notice that the transconductance is a function of the drive. For all practical considerations, therefore, an average value of the transconductance has to be taken into account.

The choice of the average transconductance value is influenced by other uncontrollable tube parameters as well. It is, therefore, rather meaningless to deduce it theoretically. We found that under certain conditions the following cutoff values fulfill the requirements of a subjectively satisfying monochromatic gray scale (practically no cutoff voltage spread at a given second grid voltage was observed in this case):

$$\left.\begin{array}{l} E_{C.R} = 30\ \mathrm{v} \\ E_{C.B} = 70\ \mathrm{v} \\ E_{C.G} = 57\ \mathrm{v} \end{array}\right\} \qquad (20)$$

For a gun with $P = 0.36$ (Eq. (12)), we find in Fig. 5 the correlated E_2-values approximately with:

$$\left.\begin{array}{l} (E_2)_R = 90\ \mathrm{v} \\ (E_2)_B = 200\ \mathrm{v} \\ (E_2)_G = 165\ \mathrm{v} \end{array}\right\} \qquad (20a)$$

It should be pointed out again that the use of an average transconductance value results in a theoretically inexact gray scale; therefore, a compromise has to be accepted. As mentioned in the previous section, this is a *conditio sine qua non*. However, experience has shown that a practical compromise can be found even without utilizing the theoretically required dynamic correction.

Thus, the systems described in Secs. 3.1 and 3.2 are equivalent concerning their practical performance. The system utilizing different cutoff voltages is simpler inasmuch as it does not require three different drives. However, the resulting E_2-spread may be unduly large provided no stringent requirements are specified for gun tolerances.

Note that changing the gun efficiencies is equivalent to changing the cutoff voltages for obtaining different current values with one drive value. This topic and the problem of avoiding the large E_2-spread will be discussed in the following sections.

4. Gamma Spread and Gamma Equalizing

4.1 Spread of Cutoff Voltages

The differences among the cutoff voltages of the three guns due to gun component and mounting tolerances (Sec. 2.4) cause a certain gamma spread (Eq. (11a)). According to tube specifications, the cutoff voltage for $E_2 = 200$ v

Fig. 4: $\Gamma_s = F(E_c)$. $\eta_M = 0.2$; $\eta = 0.8$; $K_2 = 3 \cdot 10^{-6}$; (I_s in μa; E_D in volts).

Fig. 5: $E_2 = F(E_c)$. For RCA 21-in. color tube, with $P = 0.36$; average penetration.

has to be between 45 v and 100 v at a relative cutoff spread smaller than ±22%.

By tube design, the color operation of each gun has been predetermined. It may occur that the gun with the highest cutoff is the red gun. The green gun may then have a 44% lower cutoff. The cutoff of the blue gun is restricted by the specification:

$$(E_c)_R \geqslant (E_c)_B \geqslant (E_c)_G$$

In numerical values we can write: $(E_c)_R = 90$ v, and $(E_c)_G = 50$ v. $\Gamma_R = \Gamma_B = \Gamma_G$ will be obtained for $(E_c)_R = (E_c)_B = (E_c)_G$ if the values of the other parameters of gamma are identical for the three guns. E_c can be adjusted by means of ΔE_2 (Eq. 12)). We postulate that $(E_c)_{RBG} = 70$ v (arithmetic average) and discuss $|\Delta E_2|_{max}$ for $E_2 = 200$ v. We obtain then $|\Delta E_2|_R = 45$ v and $|\Delta E_2|_G = 80$ v or:

$$(E_2)_R = 155 \text{ v}$$
$$(E_2)_G = 280 \text{ v}$$
$$155 \text{ v} \leqslant (E_2)_B \leqslant 280 \text{ v}$$

4.2 Spread of K_2

It seems necessary to discuss Eq. (6) in more detail. For $E_c = E_D$ we obtain the maximum cathode current $I_{K.0}$ with:

$$I_{K.0} = K_2 E_c^{1.5} \qquad (21)$$

The above equation represents Child's law for the particular electrode configuration used in conventional CRT guns. Child's law can be derived using Poisson's equation in axial coordinates:[3]

$$\partial^2 U/\partial z^2 = \rho/\epsilon_0 \qquad (22)$$

where

ρ = space charge density,
ϵ_0 = dielectric constant (of vacuum).

ρ depends on the emission equation, which can be written as:

$$n = \frac{A_0}{\epsilon} ST^2 \exp(-e\psi/KT) \qquad (23)$$

where

n = number of electrons emitted per time unit,
ϵ = elemental quantum,
S = emitting cathode area,
K = Boltzmann's constant,
ψ = (average) work function of the cathode surface,
T = temperature of the cathode surface (degrees K).

The emission constant A_0 is given by:

$$A_0 = G\epsilon C \frac{K}{h} \qquad (23a)$$

where

h = Planck's constant,
G = number of electrons in the highest energy level (generally two),
C = constant.

C is given by:

$$C = 2\pi mK/h^2 \qquad (23b)$$

where m is the electron mass.

We see that $K_2 = f(\psi)$ (with $\partial K_2/\partial\psi > 0$) is positively correlated with the number of free Ba- (and Sr-) atoms in the crystal lattice of the Ba-Sr-oxide coating. This number N_F depends on the state of activation of the cathode and on the unavoidable poisoning effects during the life of the tube. Deviations from the optimum value of K_2 can, therefore, be expected. $|\Delta K_2| > 0$ affects the gamma the same way as $|\Delta\eta| > 0$, expressed by Eq. (18). Therefore:

$$\Delta\Gamma = 1/\ln E_D \cdot \Delta K_2/K_2 \qquad (24)$$

$(K_2)_{EFF}$ for a gun can be computed using Eq. (21):

$$(K_2)_{EFF} = (I_{K.0})_{EFF}/E_D^{1.5} \qquad (21a)$$

and further

$$\Delta K_2 = -(3 \cdot 10^{-6} - (K_2)_{EFF}) \qquad (21b)$$

For the same cutoff we can also write:

$$K_2/(K_2)_{EFF} = I_{K.0}/(I_{K.0})_{EFF} \qquad (21c)$$

$I_{K.0}$ as a function of E_c with $K_2 = 3 \cdot 10^{-6}$ is shown in Fig. 7. Note that sometimes

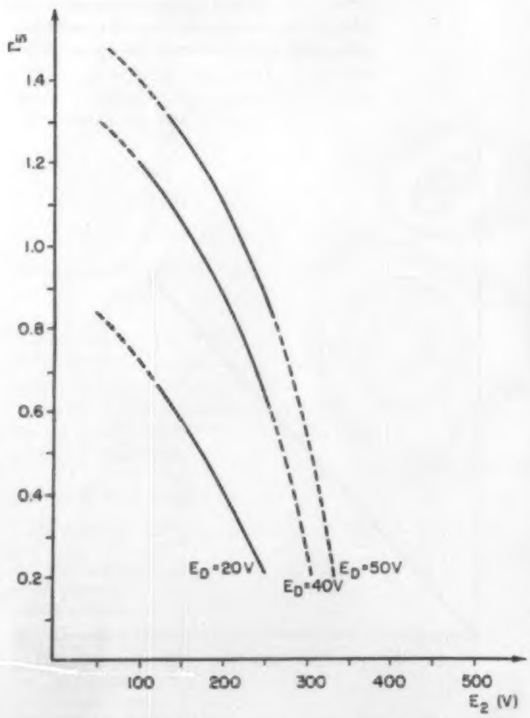

Fig. 6: $\Gamma_s = F(E_2)$. $\eta_M = 0.2$; $\eta = 0.8$; $K_2 = 3 \cdot 10^{-6}$.

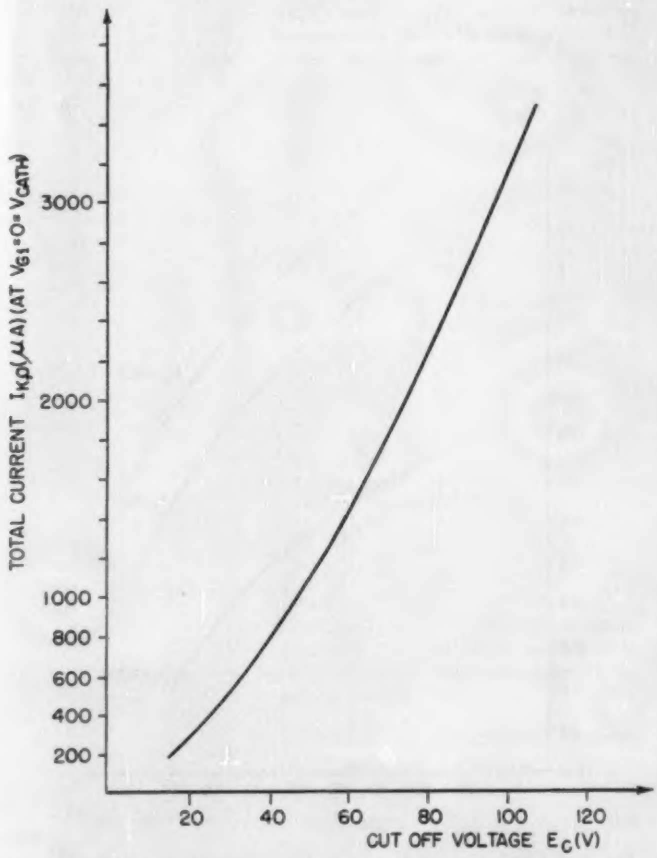

Fig. 7: $I_{K.0} = 3 \cdot 10^{-6} E_c^{2.5}$.

$(I_{K.0})_{EFF} > I_{K.0}$ may be observed. This is not caused by $(K_2)_{EFF} > K_2$ but rather by the fact that E_c is measured too low as $\partial I_K/\partial E_D \ll 1$ for $0 < E_D \leqslant 5$ v (see Fig. 2). Gamma variations according to Eq. (24) can be observed in a gun triplet at zero hour life due to differences in the state of activation of the cathode surface. On the other hand, poisoning of the cathodes by positive ion bombardment and impurity migration from electron bombarded apertures also causes a drop of K_2 over the life of the tube. This drop is not necessarily the same for all the guns. On the contrary, $(I_K)_R > (I_K)_{B.G}$ (see Sec. 3.1) seems to pre-emphasize $|\partial K_2/\partial t|_R > |\partial K_2/\partial t|_{B.G}$ leading to a decrease of gamma of the red gun.

5. Design of a Gun Triplet for Equal Drives

5.1 Unequal Cutoff Voltages

5.1.1 Unequal Spacings in the Triode: Equations (12) and (14) express E_c by the geometric dimensions of the triode. Assume D_1 and d_1 have the same value for all guns of the triplet and d_2 is different for the three guns. Assume further $(E_2)_R = (E_2)_B = (E_2)_G$.

As pointed out in Sec. 3.2, the following E_c-values have to be obtained: $(E_c)_G = 57$ v; $(E_c)_B = 70$ v; $(E_c)_R = 30$ v. We can write:

$$d_{2.B}/d_{2.G} = 0.82 \qquad d_{2.R}/d_{2.B} = 0.43 \tag{25}$$

Assume $d_2 = 0.020$ in. $\equiv d_{2.B}$

Then we obtain: $d_{2.G} = 0.016$; $d_{2.B} = 0.020$; $d_{2.R} = 0.009$. It may be assumed that d_2 has a tolerance of ± 0.003 in. We see that $d_{2.G}$ and $d_{2.B}$ are not absolutely separated, depending on the distribution function of d_2. In a practical case, overlapping of $d_{2.G}$ and $d_{2.B}$ may occur for 40% of the cases. This method, therefore, is only practical if tight tolerances of, say, ± 0.001 in. are maintained in the gun.

5.1.2. Unequal Grid 1 Apertures: E_c can be changed according to Eqs. (12) and (14) by changing the diameter D_1 of the grid 1 hole. We obtain, then, using the E_c-values of Eq. (20):

$$D_{1.B}/D_{1.R} = 1.23; \qquad D_{1.B}/D_{1.G} = 1.07 \tag{26}$$

With $D_{1.B} = 0.035$ in. we obtain:

$$\left.\begin{aligned} D_{1.R} &= 0.029 \text{ in.} \\ D_{1.B} &= 0.035 \text{ in.} \\ D_{1.G} &= 0.033 \text{ in.} \end{aligned}\right\} \tag{27}$$

The tolerance on D_1 is given by the component manufacturers as ± 0.001 in. We find, therefore, no overlapping and this method is more suitable as far as tolerances are concerned.

In Sec. 4.2, we have discussed the Γ-decrease over the life of the tube pre-emphasized by $(I_K)_R > (I_K)_{B.G}$. This effect is now stressed as $D_{1.R} < D_{1.BG}$, which increases the cathode loading of the red gun. With the cathode loading, the positive ion loading is also increased. Thus, a higher probability for poisoning exists.

5.2 Unequal Gun Efficiencies

As mentioned in Sec. 2.5, guns can be built in which the adjustment of an external voltage results in a pronounced efficiency change. Such a gun possesses an additional cylindrical electrode, g_2^1, between the second and third grids. g_2, g_2^1, and g_3 form a rather strong concentrating lens projecting a virtual image of the "crossover" into the space behind the cathode. The beam angle at the virtual crossover decreases with increasing lens strength. Thus, the gun efficiency increases.

The lens strength depends mainly on the length and the aperture diameter of g_2^1. It depends further on the external voltage E_2^1 for E_2 and E_3 constant.

As a disadvantage connected with this method, the spot size increases with increasing efficiency. Also, the strength of the main focus lens depends slightly on the gun efficiency.

In addition, the contribution of the prefocus lens to the total amount of spherical aberration of the system is substantially increased if $E_2^1 < E_2 < E_3$. A numerical estimate shows that $1 \leqslant \Delta\eta/\eta \leqslant 1.8$ seems feasible.

6. Conclusion

It is shown that gamma, as defined by Eq. (3), depends on the drive, the cutoff voltage (in turn dependent on the second grid voltage and on geometrical parameters), the gun efficiency and the quality of the cathode surface.

The method of equalizing gamma by changing the second grid voltage has been analyzed numerically.

If a tricolor tube is used with equal drives on all three guns, cutoff voltage differences have to be built into the guns. It is shown that such an effect can be obtained by utilizing different diameters for the first grid aperture, different spacings in the triode systems of the guns, and different gun efficiencies. It has been concluded that the method of using different spacings is the best one, but requires "tight tolerances" in the gun.

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An Evaluation of Certain Techniques of Using Exposure Meters

By ALLAN L. SOREM

Five methods of measuring some aspect of scene luminance or illumination have been used in connection with photographing sixteen sunlit, outdoor scenes. An exposure series was made for each scene on two motion-picture negative films. By comparing the exposures which yielded optimum print quality with those indicated by the five different exposure-meter techniques, each technique was evaluated, and the consistency with which high-quality results could be obtained was determined.

In order to establish a speed and exposure-index criterion for a class of negative photographic materials, such as black-and-white motion-picture films, it is necessary to make pictures under conditions which approximate those found in practice, with representative equipment, lighting techniques, processing and printing. An exposure series is made for each scene, from which the relationships between camera exposures, scene lighting, sensitometric characteristics and final screen-image quality of the projected prints can be determined.

A previous paper* reported the results of a series of picture tests on Eastman Background-X Panchromatic Negative Film, Type 5230, and Eastman Plus-X Panchromatic Negative Film, Type 5231. Curves were presented showing the relationship between the quality of projected prints and the camera exposures given a series of negatives. The outdoor scenes which were photographed in these tests included a wide variety of subjects. If these scenes had anything in common, it is that they were all photographed on *cloudless days* — a characteristic made necessary by the fact that the changing light from a partly cloudy sky would have made it impossible to obtain an accurate series of exposures. The data from these outdoor scenes have been used for the present paper.

Camera exposure, the independent variable for these experiments, is defined as the quotient of exposure time in seconds divided by the square of the aperture. It can be related to the exposure index of the film being used, and to some aspect of the scene illumination or luminance. Almost all exposure meters include calculators which solve the following equation to determine the required combination of exposure time and *f*-stop for a given meter reading:

$$\frac{t}{f^2} = \frac{K}{ZI} \qquad (1)$$

where t = time; f = aperture; K = constant; Z = exposure index; and I = light reading. This equation can also be used to find the exposure index which corresponds to a particular combination of camera exposure and light value.

In practice, since the photographer usually does not have an immediate choice of several films, he is more interested in determining the camera exposure corresponding to a fixed exposure index than in selecting a film having an exposure index required by a particular camera exposure. However, if it is assumed that the film exposure index is not known, then a straightforward method of determining the index is to make a series of camera exposures to a series of scenes, find out which exposures give the best-quality pictures, and then calculate the exposure index from the camera exposures and the measured light values. By averaging the indexes which correspond to the optimum exposures for several scenes, a final value is obtained.

This procedure has been followed in the study of exposure-index criteria for motion-picture negative films. The curves of quality vs. log camera exposure, which were presented in the paper previously cited, have been converted to curves of quality vs. indicated exposure index, using light values measured by each of five different exposure-meter techniques. The primary reason for doing this was, of course, to determine what exposure-index value, on the average, corresponded to the camera exposure which produced optimum quality. An examination of the data disclosed, however, that some conclusions could also be drawn concerning the relative merits of the different exposure-meter techniques.

The measurements made for each scene were as follows:

(1) An incident-light measurement was made with the meter at the subject position pointed at the camera.

(2) An incident-light measurement was made with the meter at the subject position pointed toward the sun.

(3) A measurement was made of the light reflected from a gray card held in front of the subject's face, perpendicular to the subject-camera axis.

(4) A meter with hemisphere light-collector was read at the subject position, with the top of the hemisphere toward the camera.

(5) A reflected-light reading was made at the camera position.

Figure 1 contains a summary of the results of these experiments. It shows, for each scene, the exposure-index value which, when used in Eq. (1), together with the measured light value, would give the optimum camera exposure. This exposure produced the negative from which the highest-quality print was made. The scales of daylight exposure-index values for Background-X Film are on the left and the scales for Plus-X Film are on the right. The average values of the indexes for each exposure-meter method are represented by the horizontal lines. The departures from these average values are represented by the bars above and below the line. Black bars represent Background-X Film and white bars represent Plus-X Film. The scene numbers are the same as those given with illustrations in the previously cited paper.

Since the sensitivities, and therefore the true exposure indexes, of the films are constant, any scene-to-scene variation of the indicated exposure indexes must be caused by the failure of the exposure meters to measure the really significant aspect of the scene lighting. In practice, this might be detected if the resulting pictures were seriously under- or overexposed. However, many of the variations recorded here are small enough to be well within the exposure latitude of negative materials, and would not ordinarily be detected. With color materials, however, some of the variations would produce objectionable errors in exposure.

It follows that the method of using an exposure meter which most nearly indicates the optimum exposure for each scene will be one showing the smallest range of indicated exposure indexes on this graph. By this criterion, the best method tried is that labeled "Incident Light (B)," in which an incident-light

Communication No. 1825 from the Kodak Research Laboratories, presented on October 3, 1955, at the Society's Convention at Lake Placid, N.Y., by Allan L. Sorem, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on August 24, 1956.)

* A. L. Sorem, "The effect of camera exposure on the tone-reproduction quality of motion pictures," *Jour. SMPTE*, 62: 24–44, Jan. 1954.

measurement is made by pointing the meter at the sun. The next best method is that in which incident light is measured with a meter having a translucent hemisphere light-collector over the photocell. The remaining three methods give poorer results, and there seems to be no evidence to show that any one of them is better than the others. Note that the variations in indicated indexes for the two films correlate quite well. This shows that the variability was very probably caused by the interaction of scene characteristics and meter techniques, rather than by a sensitometric property of either film.

In Fig. 2, the curves of quality vs. exposure index for Background-X Film are shown plotted together for all scenes and for two different methods of light-evaluation. The ordinate scale has been divided into five quality-categories: Excellent (E), Good (G), Fair (F), Poor (P), and Very Poor (VP). Observers who rated the prints recorded their judgments of quality on a scale of numbers from 0 to 150, which was evenly subdivided as shown. The judgment data were combined by averaging these ordinates.

The upper graph in Fig. 2 shows the curves for the reflected-light method, in which the meter is pointed at the subject. The lower graph contains similar curves for the incident-light method, with the meter pointed at the sun. Note that the curves in the lower graph are grouped more closely together. In this form, the data can be used to answer the question, "If a particular exposure index is assumed for Background-X Film, and one or the other of these meter methods is used, what level of quality can be expected from the final print?" The answer is found by averaging the ordinates at several exposure-index values, and plotting these averages. The resulting curves are shown in Fig. 3. We are most interested, of course, in the values of exposure index which will produce the highest quality with each exposure-meter technique. For the reflected-light method, if an index of 25 is assumed, a quality level of 104 is obtained, on the average, and this is the highest *average* quality obtainable with this method. Using the incident-light method, one can obtain a maximum average quality of 110 by assuming an index of 16. The difference between the assumed index values yielding maximum quality can be attributed to the calibration of the meters. The important fact is that the incident-light method, on the average, produces higher-quality results.

Figure 4 presents all of the curves of average quality vs. assumed exposure index for Background-X Film. Note that the incident-light and hemisphere methods give about the same maximum quality and that they appear to be significantly better than the other three methods. The results with Plus-X Film, shown in Fig. 5, are quite similar.

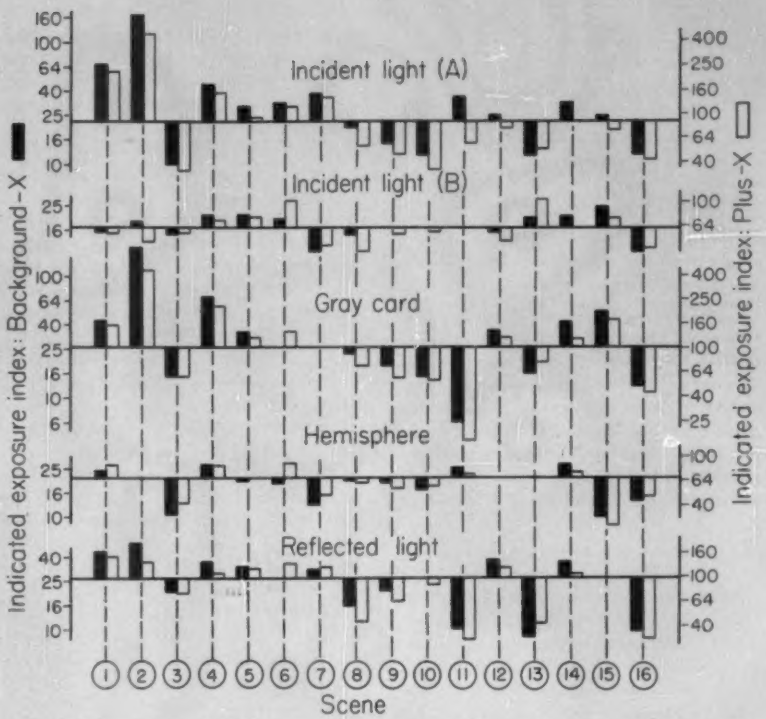


Fig. 1. Indicated exposure indexes for each scene and exposure-meter technique. The length of each bar is proportional to the difference between the average index and the index which would have produced optimum quality with the light measurement by the method indicated.

It seems appropriate to emphasize here the danger of attempting to determine an exposure index from practical tests involving only one or two scenes. The variations in indicated indexes from scene to scene, shown in Fig. 1, are large enough, even for the incident-light method, so that an incorrect impression of the index which will give the best results, on the average, might be obtained if only a few scenes were used. In addition, if, instead of making a series

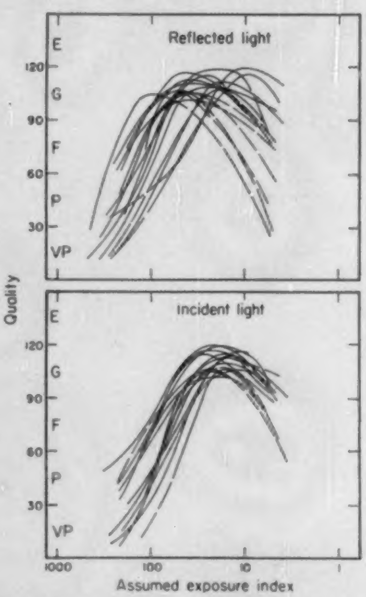


Fig. 2. Curves for individual scenes plotted together to illustrate the spread in quality with various assumed exposure indexes.

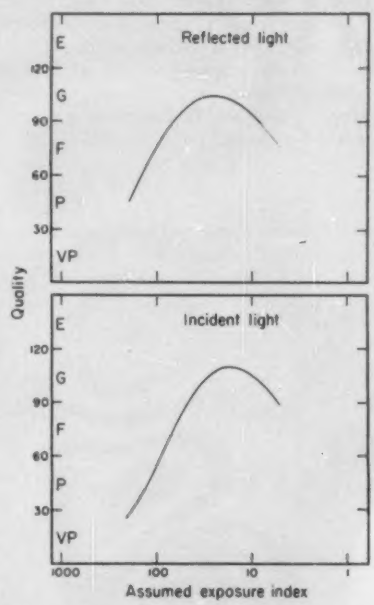


Fig. 3. Curves obtained from Fig. 2 by averaging quality values.

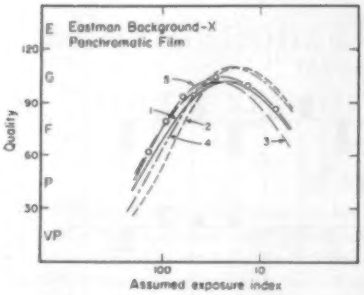


Fig. 4. Average curves of quality vs. assumed exposure index for sixteen scenes. The numbers refer to the exposure-meter techniques described and enumerated in the early part of this paper. (1) Incident light with meter pointed at camera; (2) Same, with meter pointed at sun; (3) Gray card; (4) Hemisphere; (5) Reflected light.

of exposures, only one exposure is made, then there will be no way of determining whether more or less exposure would have given a final print of higher quality, and an entirely false conclusion may be drawn from such a test. This seems to be particularly true when the tests are made by those who, for one reason or another, desire to give less exposure than would be indicated by the exposure index established for *average* conditions and maximum print quality. Such experimenters may try exposures based on an assumed exposure index several times higher than the manufacturer's rating, with one or two possibly atypical scenes. If they obtain printable negatives, they incorrectly conclude that their assumed index can be used under all conditions. Although a few photographers might be willing to accept the poor quality which will result from consistent underexposure, the majority of users benefit from the manufacturer's policy of rating films so that the best possible pictures will be obtained under average conditions.

Conclusions

Of five different exposure-meter techniques tested, the incident-light method, in which the exposure meter is held near the subject to be photographed and pointed at the sun, produces the most consistently high-quality results for sunlit scenes. Variations from the optimum exposure for each scene are smaller for this method than for the other methods tested, and therefore the average overall level of quality is highest when this method is used. Since the experimental work on which this conclusion is based was restricted to sunlit scenes, there is no evidence that a similar result should be expected for other types of scenes and other lighting conditions.

The methods of measuring some aspect of scene illumination or luminance which have been described here were chosen because they are fairly representative of those used in practice. The purpose of the experiments was not primarily to determine what method of using an exposure meter is most satisfactory, but, rather, to evaluate the films, so no attempt was made to try any but the more commonly used techniques. It is possible that minor variations of some of the techniques used in these experiments would give improved results.

Discussion

Barton Kreuzer (*Radio Corp. of America*): I think that you were studying techniques. I wonder if you considered meters at all? Is there anything in the experiments which suggests modification of the design of any of the current types of meters, or perhaps a different kind of exposure meter?

Mr. Sorem: No, I don't think we could conclude from any of our rather limited experiments that any improvements in a particular meter are indicated. We were able to draw interesting conclusions about the relative merits of different methods, and actually more than one method can be used in almost every case with any exposure meter that you happen to have available. Most of them lend themselves either to measurements of incident light or reflected light, so that you could at least have that choice.

Thomas T. Goldsmith, Jr. (*Allen B. Du Mont Laboratories*): Can you give us some details on your telephotometer type of measurement?

Mr. Sorem: For our purposes, this was the basic method of evaluating the scene, and I have not attempted to present any method for using these telephotometer measurements to determine correct camera exposures, because no method will work consistently unless a considerable amount of judgment is used. What we did was to use a modified Macbeth Illuminometer as a telephotometer to measure areas a few square inches in extent in the scene, and we tried in every case to measure the darkest and the lightest areas we could find, and several in between. These were then used in subsequent tone-reproduction studies. The same areas could be read with the telephotometer on the projection screen. In this way, you can obtain very interesting information about the compression or expansion of various portions of the scene-luminance scale. It is possible to use telephotometer measurements to determine camera exposure, but one has to be careful, when determining exposures from the area of minimum luminance, to select a significant area. Judgment is required, because it is always easy to find crevices in tree trunks or areas beneath pieces of furniture which are very dark and in which you cannot hope to reproduce detail in the final print.

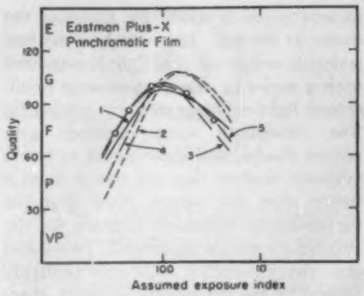


Fig. 5. Curves similar to those in Fig. 4 for Eastman Plus-X Panchromatic Negative Film, Type 5231.

Paul Klingenstein (*Kling Photo Corp.*): Did you use the same exposure meters in all five different methods of reading, or did you use different instruments?

Mr. Sorem: We used different instruments.

Mr. Klingenstein: Did you then consider the angle of acceptance, particularly in making your incident-light reading?

Mr. Sorem: Yes, we did. In the case of the two incident-light readings, the first and the second, in which the meter was pointed first at the sun and next at the camera, we used the same meter for the two techniques. A different meter was used for the reflected-light measurement from the camera position and still another meter was used with the hemisphere for incident-light measurement. When we started out to do this work, we were most interested in knowing what the average user of these films would find with any one of these commonly used techniques if he were making the exposure on the scenes that we used, so we would have some indication of what the indicated exposure indexes would be under those conditions. Then, as we studied the data, it became evident that one could hope to obtain higher quality, on the average, if the proper choices of meter methods were made.

Several Films for Use in High-Speed Motion-Picture Photography

By W. E. HUMM
and A. E. QUINN

Changes are being made among the highest emulsion speed 16mm films supplied by the Eastman Kodak Co. for high-speed motion-picture photography. During the past year films having improved speed-graininess-definition properties have become available. Some of the older films are being discontinued. Sensitometric test data are presented showing the speed relationship of these films to one another for various conditions of use and the speed and quality relationships found in practical high-speed picture tests are discussed.

From the standpoint of high emulsion speed, the Eastman Kodak Co. has available at the present time five different 16mm films which are particularly suitable for use in high-speed motion-picture photography. The five films are Cine-Kodak Super-XX Film (Type 5261), Cine-Kodak Tri-X Reversal Film Type 7278 (recently changed from Type 5278), Kodak Linagraph Pan Film (Type 5244 — original type), Kodak Linagraph Pan Film (Type 5244 — modified, improved type), and Cine-Kodak High Speed Infrared Film (Type H5218).

The first two of these films are intended for reversal use. Of these, 5261 has a jet antihalation backing of high density which is not readily removed in typical negative development processes. This prohibits its use as a negative film. On the other hand, Tri-X Reversal Film, which became available about midyear last year, is coated on a gray-dyed antihalation film base similar to that used for black-and-white professional motion-picture negative films. Therefore Type 7278 can be used as a negative film even though it is not designed primarily for such use.

The other films, Cine-Kodak High Speed Infrared Film and the improved and old types of Kodak Linagraph Pan Film, are intended for negative use only. Of these, the high-speed infrared-sensitive film should be considered as a very limited special use high-speed film. It will have particular advantages over either of the other two only when the subject illumination is relatively high in the infrared region of the energy spectrum as compared with the visual region. The improved Linagraph Pan Film is of the same emulsion family represented by Eastman Tri-X Panchromatic Negative Film, Types 5233 and 7233. Such emulsions offer impressive improvements in speed-graininess-definition relationships as compared with earlier emulsion types.

Two of the presently available five films, which make use of these earlier type emulsions, are being discontinued. They are the original Linagraph Pan Film and the Cine-Kodak Super-XX Film. Thus, for general high-speed motion-picture use there will remain only two unusually high emulsion speed Kodak films — one designed for negative use; the other designed for reversal use but capable of being used as a negative film as well.

An additional film has been included in the tests even though its emulsion speed level does not justify classifying it as a high-speed film. This is Cine-Kodak Plus-X Reversal Film (Type 7276). It is a modified version of the Cine-Kodak Plus-X Reversal Film, Type 5276. It represents a substantial improvement over the latter with respect to definition and graininess, tolerance of deviations from recommended reversal processing conditions and tolerance of higher-than-conventional processing temperatures. It is expected that it will be available in the near future.

Presented in condensed form on May 3 at the Society's Convention at New York by W. E. Humm (who read the paper) and A. E. Quinn, Kodak Park Works, Eastman Kodak Co., Rochester 4, N.Y.
(The revised and extended paper was received on June 20, 1956.)

Test Procedures — General

To carry out the sensitometric and practical picture tests, film samples were obtained from typical coatings of approximately equal age. On the basis of the routine fresh sensitometric tests made by Kodak's Film Testing Division, all were within 10% of "aim" product in speed and contrast for their respective film types.

With the purpose of avoiding reciprocity effects that might upset the correlation between the sensitometric tests and the picture tests, an electronic flash (Kodatron) sensitometer was used in making the sensitometric exposures. This particular sensitometer was designed by and built for the Kodak Park Film Testing Division who use it in their routine sensitometric testing of certain types of Kodak films. It makes use of a Kodatron Power Pack and a General Electric FT-403 Xenon Flash Lamp as the light source. A carbon step-tablet is used to modulate the exposure. With this sensitometer an exposure time of essentially 1/15,000 sec can easily be realized. This is comparable with the exposure times used in our high-speed camera picture tests.

To approximate daylight-quality illumination, a Kodak Wratten Filter No. 2B was used to cut out the excess of ultraviolet energy the xenon lamp produces; to approximate tungsten quality such as used in our practical picture tests, a Kodak Wratten Filter No. 85 was added to the setup.

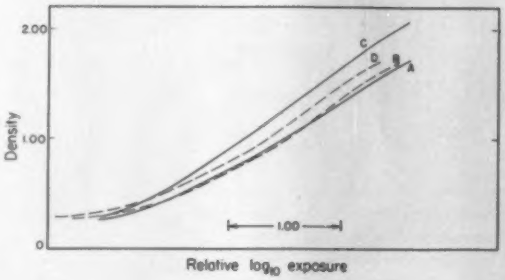
In high-speed photography a negative image of the subject under study often will supply the desired information just as satisfactorily as a positive image. In this case the high-speed photographer may wish to take advantage of the higher emulsion speed he can realize by having his negative film developed to a higher degree. Accordingly, a high degree of development was allowed for as well as the lower degree typical of professional motion-picture laboratory practice when considering the various films for negative use.

The speed relationships of an infrared-sensitive negative film to conventional panchromatic negative films under conventional sensitometric testing conditions is of little significance. Therefore Cine-Kodak High Speed Infrared Film was not included in the test data. In practical use, the speed advantage of such a film will depend upon what proportion of the total available radiant energy for exposure of the subject is in the infrared region of the spectrum. It can be many times faster than the fastest of the other films if the subject exposure energy is relatively very high in the infrared and very low in the visible region of the spectrum.

Sensitometric Tests — Negative Films and Reversal Films Used as Negative Films

The sensitometric test data for the two negative films (original Linagraph Pan and improved Linagraph Pan) and for the two reversal films (Cine-Kodak Tri-X and Cine-Kodak Plus-X) when developed in a typical motion-picture negative developer of the modified D-76 type are given in Table I. In this case Kodatron daylight sensitometric exposures were used. Relative speeds have been determined and tabulated for the development times required to give matched sensitometric contrasts and for a fixed development time of 20 min.

Fig. 1. Curve-shape relationships for "matched gamma" vs. "matched contrast" as a criterion for controlling degree of development.



Curve A: Improved Kodak Linagraph Pan Film, 8-min devel. at 68 F in modified D-76 type developer.
Curve B: Regular Kodak Linagraph Pan Film, 12-min devel. at 68 F.
Curve C: Improved Kodak Linagraph Pan Film, 12-min devel. at 68 F.
Curve D: Curve B arbitrarily shifted along log E to intersect Curve C at a density of 0.20 above fog plus base density. (Only Curves A and C are shown in their correct speed relationships.)

Table I. Sensitometric Test Data.

Exposure: Kodatron Sensitometer using a General Electric FT-403 Xenon Flash Lamp and Kodak Wratten Filter No. 2B.
Development: Sensitometric Strip Developing Machine; typical modified D-76 type motion-picture negative developer; temperature, 68 F.
Speed: Relative. Calculated from exposures required to obtain density of 0.20 above fog plus base density.

	Matched contrast values		Values for 20-min-development		
Film type	Speed	Time	Speed	Gamma	Fog
5244 (Improved type)	100	10.0′	145	0.81	0.06
5244 (Old type)	63	14.0′	93	.83	.08
7278	19	5.2′	55	1.46	.05
7276	5.7	4.5′	15	1.25	.05

For the "matched contrast" condition the contrast level is that typical of professional motion-picture negatives aimed at giving excellent photographic quality when printed onto a positive film such as Eastman Fine Grain Release Positive Film, Type 7302. It corresponds to a gamma value of about 0.70 for the improved Kodak Linagraph Pan Film. The curves in Fig. 1 demonstrate how matched gammas as a criterion of matched negative contrasts would be misleading and would result in false speed relationships.

Curve A represents an 8-min development of the improved Linagraph Pan Film, while Curve B represents a 12-min development of the old Linagraph Pan Film. The average contrast match of these curves is fairly good, although the gamma for the latter is 0.76 as compared with 0.66 for the former. Curve C represents a 12-min development for the improved Linagraph Pan Film, and Curves C and D show the failure to obtain the contrast match that would occur if matched gammas were to be used as a criterion for determining development conditions that give matched picture negative contrasts.

For this matched gamma condition, the improved Linagraph Pan has double the speed of the old Linagraph Pan, while for the "matched contrast" condition the improved Linagraph Pan is only 50% faster than the old type. Curves B and D have been shifted along the log exposure axis arbitrarily to match Curves A and C at a density of 0.20 above fog and base density in order to permit the curve-shape relationships to be seen more easily.

The sensitometric data given in Table II were obtained in the same manner as for Table I except for the addition of a Kodak Wratten Filter No. 85 when the sensitometric strips were exposed.

Table II. Sensitometric Test Data.

Exposure: Same as Table I tests except Kodak Wratten Filter No. 85 added.
Development: Same as Table I tests.
Speed: Determined in same manner as for Table I but not directly comparable with those speed values.

	Matched contrast values		Values for 20-min development	
Film type	Speed	Time	Speed	Gamma
5244 (Improved type)	100	9.9′	150	0.83
5244 (Old type)	80	14.0′	115	.85
7278	20	5.1′	55	1.52
7276	5.1	4.4′	16	1.33

It will be noted that the improved Linagraph Pan Film shows the highest speed of any of the films, although the old type Linagraph Pan Film is only slightly slower for the simulated tungsten-exposure conditions. The two reversal-type films rate particularly poorly for emulsion speed under the "matched contrast" condition because of the short development times required. Their speed relationships are improved considerably for the 20-min development but their contrasts are then considerably higher than is the case for the two Linagraph films.

The higher speed of the old Linagraph Pan compared with the improved Linagraph Pan Film for the tungsten type exposure is a consequence of its relatively high sensitivity in the red region of the spectrum. All of the other films are essentially alike with respect to the distribution of their total emulsion sensitivities over the blue, green and red regions of the spectrum. The old Linagraph Pan Film, however, has a much higher proportion of its sensitivity in the red region of the spectrum and lower proportions in the blue and green regions.

Sensitometric Tests — Reversal Films Used as Reversal Films

The sensitometric approach to comparing the reversal films has been essentially the same as that followed for the negative films except for processing. The three reversal films, Cine-Kodak Super XX (5261), Cine-Kodak Tri-X Reversal (7278) and Cine-Kodak Plus-X Reversal (7276), were processed in accord with reversal processing procedures recommended by Kodak for these films when using commercial processing equipment such as the Houston Model 22 Reversal Processing Machine. The data from tests similar to those covered by Tables I and II are given in Table III.

Table III. Sensitometric Test Data.

Exposure: As indicated.
Development: Houston Model 22 Reversal Processing Machine; Kodak recommended reversal processing. (This involves a 2-min first development for 7278 and 7276 and a 4-min first development for 5261.)
Speeds: All relative to an arbitrary value of 100 for 5261 and calculated at three different density levels and for a fixed shoulder gradient value as indicated.

	Relative speed				
Film type	@D = 0.50	@D = 1.00	@D = 1.50	@G = 0.60	Gamma
1/15,000 Second Kodatron Daylight Exposure					
5261	100	100	100	100	1.35
7278	130	180	200	150	1.06
7276	24	26	27	38	1.27
1/15,000 Second Kodatron Tungsten Exposure					
5261	100	100	100	100	1.42
7278	140	190	220	140	1.13
7276	26	26	28	34	1.31

For reversal films there is a problem with respect to the best way to rate emulsion speeds in order to have the sensitometric tests do a good job of predicting what practical picture tests will show. The nature of this problem is illustrated by the curves in Fig. 2. It should be easy to see that a person's judgment of the practical picture speed relationships of these two films will not be the same if his principal interest is in the highlights (low density region of the sensitometric curves) as it will be if his principal interest is in the shadows (high density region of the sensitometric curves).

Since we are concerned with using the films in high-speed motion-picture photography, it seems reasonable to assume that our interest should be focused more on the underexposure or shadow region of the sensitometric curves. Even though this is the case, there is still

a question of whether it will be better to determine speed in terms of the exposure required to produce a fixed density or in terms of the exposure required to obtain a fixed gradient on the shoulder of the reversal curve.

In these tests speed measurements were made at density values of 0.50, 1.00 and 1.50 (above base density in the case of the two gray-base films, 7276 and 7278). In addition, a speed measurement has been made based on the exposure required to produce a gradient of 0.60 on the shoulder of the reversal curve. All of the speeds are on the basis of assigning a value of 100 to 5261 for each condition and rating the speeds of the other two films relative to it.

A fixed gradient speed evaluation would probably be best for our purposes except for the fact that when picture densities get up around 2.00, the intensity of the light reaching the screen is so low from most 16mm projectors that even though useful picture information may be recorded in the film above this density, it is blocked up during projection and cannot easily be seen. The tendency therefore when making practical picture test comparisons of two films having reversal curves like those shown in Fig. 2 will be to rate the speed difference as greater than that shown by our 0.60 gradient values and perhaps somewhat more nearly that shown by our D = 1.50 values. In any event, for processing conditions similar to those used for the tests of Table III, we would expect the practical picture test speed of 7278 to be between one and one-half and two times as great as that of 5261.

Graininess and Definition Relationships

Graininess and definition should be of some importance in evaluating the relative merits of several films for high-speed photography use. For the purpose, of these tests the relationships of the films for these properties can be evaluated very well from the practical picture tests.

Practical Picture Tests

The films were exposed in a Kodak High Speed Camera (Type III) at a rate of approximately 3,000 pictures/sec for our practical picture comparisons. Under this condition, the exposure time for each picture frame is 1/15,000 sec. A Kodak Cine Ektar, 25mm, *f*/1.9, Luminized Lens was used at a working distance of 4 ft. The test subject (Fig. 3) was illuminated with six General Electric R-40 lamps rated at 750 w at 115 v. These were positioned approximately 24–36 in. from the subject in an arrangement to produce highlight and shadow conditions typical of subjects encountered in practical high-speed motion-picture photography.

A series of exposures was made with each film for each processing condition. Only the two Linagraph Pan Films and the Cine-Kodak Tri-X Reversal Film were included in the tests developed to the low matched contrast level similar to our Table II sensitometric tests. The improved Cine-Kodak Plus-X Reversal Film (Type 7276) was not included because of its low speed level for this processing treatment. The pictures were actually developed in a continuous processing machine like those commonly used in commercial professional motion-picture film laboratories.

Under these processing conditions, the development times required for matched sensitometric contrasts similar to those in Table II tests were 8 min for the improved Linagraph Pan, 15 min for the old type Linagraph Pan, and 5 min for the Cine-Kodak Tri-X Reversal. The relative speeds from the Kodatron tungsten-exposed sensitometric control strips developed with the pictures were 100, 105 and 22, respectively. When allowance is made for the longer relative processing time required for the older type 5244 in these tests, the agreement with the sensitometric data in Table II is excellent.

The pictures themselves bear out these speed relationships and show a very impressive advantage in definition and graininess for the improved Linagraph Pan Film over the older type.

Kodak Developer D-19 was used to demonstrate the capabilities of these same films under conditions of very full development aimed at getting the highest negative speed. In these tests the pictures were developed by rack and tank for 8 min in D-19 at 70 F. The speed of 7276 was sufficient under these conditions to include it in the tests. The sensitometric curves obtained from the Kodatron tungsten-exposed control strips processed with the pictures are shown in Fig. 4. The relative speeds

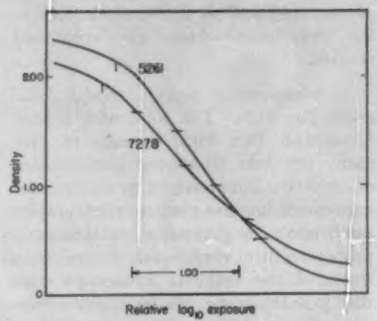


Fig. 2. Curves (reversal processing) showing the dependence of numerical speed ratings on curve-shape and point on curve at which speed rating is to be measured.

(at a density of 0.20 above fog plus base density) were 100, 100, 65 and 15, respectively, for the two Linagraph Pan Films, the Cine-Kodak Tri-X and the Cine-Kodak Plus-X. The two reversal films show appreciably higher contrast than the two negative films, of course.

Again, the pictures confirm these sensitometric relationships and show the improved 5244 to be impressively better for graininess and definition than the older type it is replacing.

The picture tests on the three reversal films, 5261, 7278 and 7276, processed as reversal films were given the same reversal processing treatment as that used for the sensitometric tests covered by Table III. The sensitometric control strips which were processed with the pictures gave essentially the same relationships as shown in Table III and Fig. 2.

Conclusions

Excellent correlation was obtained between the sensitometric and practical

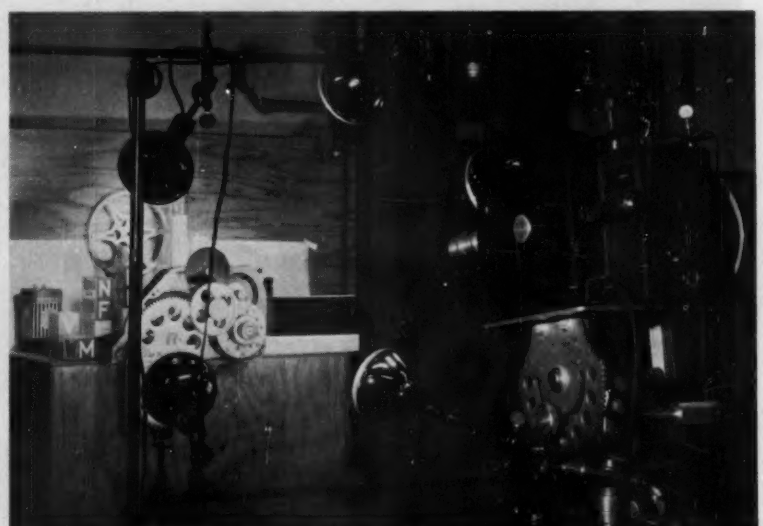


Fig. 3. Test object, camera and lighting arrangement used in practical picture tests.

picture tests and we arrive at the following conclusions from the combined studies:

1. Advantages of improved Kodak Linagraph Pan Film: The improved Kodak Linagraph Pan Film appears to give easily the best all-around performance of any of the films covered by our tests for high-speed motion-picture photography application. Its graininess and definition properties are very much better than those of the original Linagraph Pan that it is replacing. Under many conditions of use its speed will be greater than than of the latter. It will be at least as high as that of the original Linagraph Pan for conditions of tungsten exposure and forced development.

Furthermore, the sacrifice in ultimate speed capability is far less for this film when it is developed in a commercial laboratory under standard professional motion-picture negative conditions than for the older Linagraph Pan Film. The new film has been designed to perform particularly well under this processing condition which is generally conveniently available.

The new film has excellent exposure latitude, lends itself readily to projection use as a negative or as a negative from which prints are to be made for projection use. Even when development is forced to obtain the limit of its potential speed, its contrast will not be excessively high.

2. Advantages of Cine-Kodak Tri-X Reversal Film: When there are reasons for preferring a reversal film such as the desire to obtain directly a positive image of the subject, Cine-Kodak Tri-X Reversal Film will provide an adequate emulsion speed for high-speed motion-picture needs and represents an improvement over Cine-Kodak Super-XX Film by giving effectively one-half to one full camera stop more speed with slightly better definition and no sacrifice in graininess.

Used as a reversal film, its effective speed is about one camera stop less than that of the improved Linagraph Pan Film used as a negative. When processed as a negative film, it is very important that Cine-Kodak Tri-X receive a high degree of development such as 8 min in D-19 if its full speed capabilities are to be realized. Its speed is then within about one-half camera stop of that of Linagraph Pan and its graininess and definition are approximately the same as for the improved Linagraph Pan. Its contrast will be considerably higher, however, and under some situations might be objectionable.

3. Advantages of Cine-Kodak Plus-X Reversal Film: When adequate exposure is readily available, the improved Cine-Kodak Plus-X Reversal Film will give the highest picture quality of any of the emulsions.

4. Advantages of Projecting a Negative Image: In high-speed motion-picture photography, projection limitations make it advantageous to use a negative film and to project it as a negative film in order to get the information from it. This is especially desirable when there is great difficulty in obtaining adequate exposure of the subject under study. This difficulty occurs because readily available projectors do not have sufficient intensity of illumination to permit information which is in the film to be seen easily if this information is recorded at densities of about 2.00 or higher. When projecting the film as a negative, of course, the underexposure information is all at low densities and projector illumination intensity is no problem in making it easily seen.

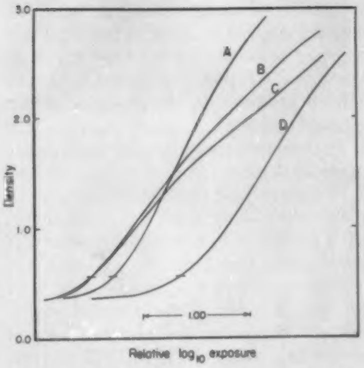


Fig. 4. Control curves from test strips processed with practical picture test films.

Curve A: Cine-Kodak Tri-X Reversal Film.
Curve B: Regular Kodak Linagraph Pan Film.
Curve C: Improved Linagraph Pan Film.
Curve D: Cine-Kodak Plus-X Reversal Film.
Exposure: Kodatron Tungsten.
Development: D-19, 8 min at 70 F.

One aspect of this is that ordinarily judgment of the emulsion speed relationship of a reversal film to a negative film on the basis of practical picture comparisons is biased in favor of the negative film. Another aspect is that a reversal emulsion on a gray base such as Cine-Kodak Tri-X is rated as being slightly slower in terms of practical picture performance than the same emulsion on a clear base.

Discussion

J. M. Novajosky (Allison Div., General Motors Corp.): Is work being done to produce high-speed Ektachrome for high-speed cameras?

Mr. Humm: Work is in progress with the purpose of obtaining a 16mm color film of the Ektachrome type which will have considerably higher speed than Kodachrome. Of course this film must have satisfactory photographic quality as well. At the present time, I am unable to say just when such a film will become available.

After Two Years of Local Color Origination

By PHILIP W. WYGANT

This paper explains how the changeover from black-and-white to color affected studio lighting at WBAP-TV. The number of watts per square foot for studio floor space was increased from 18.5 to approximately 60. The air-conditioning capacity was almost doubled. A light level of 400 ft-c was found to be practical. Recognizing that methods of operation vary from studio to studio, the author is not suggesting that methods found satisfactory at WBAP-TV could be applied with equal success to all studios, but some helpful ideas may be gained from a review of the experience of one studio.

THE STUDIO which was converted for color TV lighting was in use for monochrome from 1948 to 1954.

Before color, the studio used three 150-kva main transformers. With the addition of greater lighting loads three more 150-kva transformers were added to bring the total capacity to 900 kva. These six transformers are the property of WBAP-TV, and primary power is purchased from the service company.

The heat exchanger presented another problem. Two 100-ton air-conditioning compressors were already in use. A 60-ton compressor was added to the existing chilled water lines and these lines were extended to the heat exchanger. It is mounted on the roof of an adjoining building, and the ducts are fed into the end of the studio then over the grid throughout the length of the studio. This had the effect of almost doubling the air-conditioning capacity.

Three secondary bus transformers are located in the power vault below the TV studio. A 150-kva transformer was added to supply Studio 1 with power for lighting. The second 150-kva transformer is also used for Studio 1 lighting, plus supplying 200-amp, 120–208-v, 3-phase service to Studio 2. The third transformer supplies regulated power for the control-room equipment and stand-by transmitter.

The old switchboard had the disadvantage of being located 14 ft above the studio floor on a catwalk. It was quite inconvenient to have to go so far to operate the lights.

The old board consisted of 140 mercury switches which were installed in the interest of silence. Independent of this board was a homemade 12-kw dimmer board. It was very difficult to use since it was necessary to run an extension cable out over the grid from the dimmer to the fixture.

The mercury switches in the studio board would handle only 10 amp each. Since the load circuits were 20 amp each, it was necessary to use these remote-control relay contactors. Using these produced some maintenance difficulties.

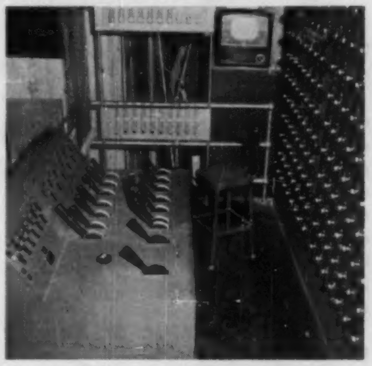


Fig. 1. Dimmers and rotary selector switches installed for color use.

The load circuits were fed from the relay contactors above the studio grid in the 4-in. square electrical ducts with hinged covers. Space was available in these ducts for additional wiring, so they continue in use. All the previously used wiring and receptacles were incorporated in the color lighting setup, and some receptacles were added.

One of the major additions for color was a switch and dimmer board with a total capacity of 1800 amp (Fig. 1). There are 12 100-amp non-dim sub-breakers, 12 5.5-kw variable transformer dimmers on 12 50-amp sub-breakers. There are, of course, main dim and non-dim fused switches and master dimmer controls.

A rotary selector switch board provides a convenient method of cross-connecting the load circuits with the supply circuits. Twenty-four point rotary selector switches are used corresponding to the 12 dim and 12 non-dim circuits on the switchboard. There is a total of 150 of these switch units. One hundred forty have 20-amp capacity and 10 have 50-amp capacity. The 12 ammeters across the top meter the dimmer circuits to allow the operator to load the dimmers to their full capacity.

With the old lighting setup (Fig. 2), the studio was 82 ft long, 45 ft wide and 28 ft high, with a pipe grid 20 ft from the floor. Banks of incandescents contained both PAR-38 and R-40 lamps. These

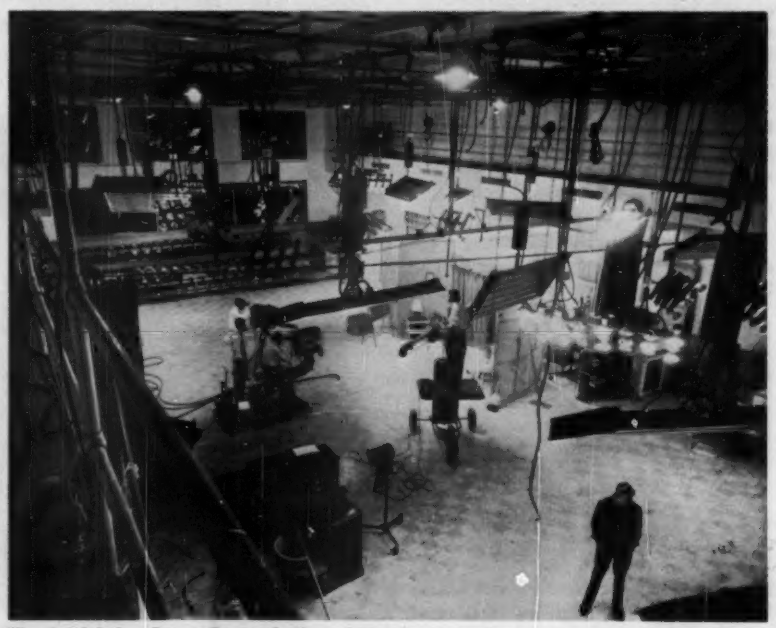


Fig. 2. Lighting fixture in use before changeover to color.

Presented on May 2, 1956, at the Society's Convention at New York by Philip W. Wygant, WBAP-TV, 3900 Barnett St., Fort Worth, Tex. (This paper was received on June 28, 1956.)

Fig. 3. Lighting fixtures as used for color.

were on separate circuits with the PAR-38's used for modeling light and the R-40's for fill. There were 15 fluorescent fixtures using 64-in. slim-line tubes. All of these fixtures had turn-and-tilt adjustments that were controlled by means of strings running to alongside the switchboard. There were 18.5 w/sq ft of studio floor space.

In the changeover to color, 50 18-in. 2-kw scoops were added along with 30 8-in. 2-kw spots (Fig. 3), and the fluorescent banks were taken down. This was not because of any adverse experience with the light quality but because of their physical size. The turn-and-tilt controls were retained and some of the scoops were installed on similar devices. The switchboard is located on a platform 3 ft above the studio floor (Fig. 4). Loss of valuable floor space is compensated for by the saving in power costs. It is now possible to keep the lights off unless they are actually in use.

Operation

The 12 lamp banks of incandescents are still used for modeling and fill light. The light from these fixtures is not as controllable as might be desired but they do put out a large quantity of light.

The 50 2-kw scoops (Fig. 5) are the real backbone of color lighting in the studio. In general practice diffusers are not used. The boom shadow problem is not too actute from scoops because of the large number of fixtures used on any one set. If there is a boom shadow it is usually caused by a spot that is being used for modeling light and the spot can be readjusted.

The fixtures are not readily movable from one position to another. There are good arguments for both fixed and movable fixtures, but the fixed has been found to be preferable because it takes less labor to set up the lighting for each program. The catwalk has many advantages, but it has come to be less frequently used than in the old studio.

Conclusions

The ratios of key to fill to back light used for black-and-white still apply to color. However, we have found that it is very important to have the light level uniform throughout the set. Because it is rather difficult to use a strong key light and maintain uniformity and because of the studio's fixed light source setup, a more or less flat light is ordinarily used. Whether this is advisable is debatable. The opinion has been expressed that not as much back light is needed for color as for black-and-white, but in the opinion of the author, back light is an extremely necessary part of studio lighting and should never be underestimated. Also, it takes a good bit of back light to show up under the 400 ft-c of front light.

The studio is currently operated with 400 ft-c of front light and 500 to 600 ft-c of back light. The back light level is, of course, determined by the color of dress, hair, etc. The lighting fixtures in use provide approximately 60 w/sq ft of floor space as compared to 18.5 for black-and-white. However, it should be kept in mind that it is possible at any given time to light only one end and one side of the studio. If there were an arrangement whereby the entire studio wall surface could be lit to 400 ft-c, then there would probably be close to 90 or 100 w/-sq ft. In two years of operation there has never been a situation where it was not possible, by careful location of sets and by use of the turning adjustments, to light any type of program.

Color temperature does not seem to be of major importance. The reason the fluorescent fixtures are not used is because of their physical size, rather than color temperature output. Some day we want to experiment with some of our old

Fig. 4. Studio setup showing location of switchboard.

Fig. 5. Studio during color telecast.

fixtures and see what effect they have on the color picture. All of the incandescent fixtures are operated with general service lamps. Lamps are taken out of service not because of their color temperature which changes with age, but because of their lower intensity output.

Dimmers are extremely useful, and there again, theoretically there should be a color temperature problem. If a scene is dimmed relatively fast, no appreciable difficulty can be observed. Of course, we would never leave all of the lights dimmed say at three-fourths intensity. In the majority of cases it is desirable to have at least a pin point of light on the people in a scene although the back ground may be black. A 400-ft-c level should be maintained on people to preserve the skin tone no matter what is being done to the surrounding area.

Naturally with more fixtures to adjust it takes longer for the lighting man to set up the lighting, although with more experience in handling lighting for color, the setup time has greatly decreased.

In lighting a black-and-white set a few mistakes can be tolerated for they do not show up too badly on the screen. Lighting a color set is much more critical. Any small error in lighting can show up prominently, as a change in skin tone, for example.

The use of light meters is essential! When light levels approach 400 ft-c, the eye cannot detect small variations. Brightness meters have been found very useful, particularly in lighting a new set for the first time. For average day-to-day operation, however, a small incident meter is sufficient and is easy to operate. There seems to be a large discrepancy between incident meters of different manufacturers, so it is advisable to standardize and also to recalibrate the meters occasionally.

Lighting for color definitely requires an operator who has artistic ability. This is more essential than for black-and-white, and particularly when colored light is used for background.

Starting into color TV before there are a great number of receivers in use gives a station a good opportunity for experimentation just as it did in black-and-white.

In conclusion, the author emphasizes that lighting for color is not impossible or even very difficult. Lighting is a very important part of a good picture and it does take more equipment and time, but the problems are not insurmountable.

Erratum

C. H. Evans and R. B. Smith, "Color kinescope recording on embossed film," *Jour. SMPTE, 65:* 365–372, July 1956 (Communication No. 1806 from the Kodak Research Laboratories).

On p. 369, in the middle column, below Fig. 8 —

For: "It is found that the tangent of twice the angle × *i* is 2.3. This means . . ."

Read: "It is found that half the cotangent of the angle *i* is 2.3. This means . . ."

A List of Motion-Picture Technical Terms in Five Languages — Additions

Since this list, originally organized by Carlos Connio Santini, was published in the February 1956 *Journal* we have received a number of comments, additions and corrections from readers. Suggested improvements, additions or variant terms having some currency have been received from J.-M. Fred Jeannot, of Fred Jeannot, 86 Rue de Sévres, Paris 7; Raymond Spinnox, of Gevaert Photo-Producten, Mortsel (Antwerpen), Belgium; and Jean Vivié, of the Commission Supérieure Technique, 92 Ave. des Champs-Élysées, Paris 8. The suggested additions and variants to the list of French terms are shown below. Later, if some other commitments to provide additional Spanish and Portuguese versions are fulfilled, a complete revised list will be printed. Until then, readers may wish to edit their original copies with the terms given here. Page numbers refer to the February *Journal* in which the original listing may be found. Victor Volmar, Latin American Manager for Allied Artists International Corp., has called to our attention a similar but more comprehensive glossary (excluding Spanish) which is described in the *Journal*, August, 1956, p. 450.—*Ed.*

Page no.	*English*	*French*
85	Composite-reversal original	Original inversible combiné image et son
	Contact printing	Copie par contact
86	Frameline	Barre de cadre *or* séparation d'images
	Original sound negative	Négatif original son
	Optical printing	Copie par tirage optique
	Release print	Copie de série *or* copie d'exploitation
87	Treatment	Adaptation
	Blimp	Caisson insonore
	Footage counter	Compteur de métrage
88	Portable camera	Caméra à main
	Sprocket	Tambour denté
	Drive sprocket	Tambour d'entrainement
	Feed sprocket	Tambour d'amenée
	Hold-back sprocket	Tambour de retenue
	Studio camera	Caméra de studio
	Tripod	Pied
	Tripod head	Tete de pied
	Power supply	Alimentation
	Condenser (optical)	Condenseur
	Fill light	Lumière d'appoint
	Jelly	Ecran de gelatine
	Reflector	Ecran réflecteur
89	Silk	Diffuseur
	Printing card	Fiche d'étalonnage
90	Start leader	Amorce de départ

news and reports

Awards by Photographic Societies in the United States

[A report contributed by Glenn E. Matthews, Technical Editor, Research Laboratories, Eastman Kodak Co., Rochester 4, N. Y.]

THREE NATIONAL photographic societies in the United States have established awards specifically designated for photographic progress — the Society of Motion Picture and Television Engineers, the Photographic Society of America and the Society of Photographic Engineers. The first two societies named have several other awards that are given for outstanding research or meritorious contributions in fields of photography. A few specialized awards related to photography have also been established by other national societies in America.

Society of Motion Picture and Television Engineers (Founded in 1916)

This society established their gold Progress Medal in May 1931. This medal may be awarded annually by the Board of Governors of that Society "in recognition of any invention, research or development, which in the opinion of the Progress Award Committee shall have resulted in a significant advance in the development of motion picture technology."[1] The first recipient of the SMPE Progress Medal was Dr. Edward C. Wente of Bell Telephone Laboratories who in 1935 was cited for his work in sound recording and reproduction. The list of awards usually is published each year in the April issue of the *Journal* of the SMPTE.

Other awards given by the Society of Motion Picture and Television Engineers are as follows:

Journal Award for the most outstanding paper originally published in the *Journal* of the Society during the preceding calendar year. The first award was made in 1935.

Samuel L. Warner Memorial Award recognizes outstanding contributions in the design and development of new and improved methods and/or apparatus for sound on film motion pictures. First award was made in 1947.

David Sarnoff Gold Medal Award in recognition of recent technical contributions to the art of television to encourage the development of new techniques, new methods and new equipment which hold promise for the continued improvement of television. First award was made in 1951.

Herbert T. Kalmus Gold Medal Award was conceived to honor major contributions to the scientific progress of color in motion pictures. The first award will be made in 1956.

The awards of the SMPTE were described and illustrated in the April 1956 *Journal*, Part II.

Photographic Society of America

The Photographic Society of America was founded in 1934 as an outgrowth of the Associated Camera Clubs of America, which in turn was started in 1919.

The bronze Progress Medal Award of the Photographic Society of America was contributed by the Oval Table Society as a result of the interest shown by the late Joseph M. Bing of New York, N.Y. The award is made by the Progress Medal Committee of the PSA. The medal is awarded annually, providing a deserving person is nominated and accepted, to a person who has made an outstanding contribution to photography or an allied subject.[2] The first award of this medal was made in 1948 to Dr. C. E. K. Mees, Vice-President in charge of Research for the Eastman Kodak Co. The citation accompanying the presentation reads in part "for his work in photography; for his technical achievements; for his documenting of his work and important contributions to photographic literature, for his inspiration to his corps of fellow workers."

Other special awards[3] given by the PSA include:

The Journal Award for the best scientific or technical paper published originally in an official publication of the PSA.

Clerk Maxwell Award the purpose of which is to stimulate interest in color print making and to preserve examples of the best color prints made by amateurs.

Stuyvesant Peabody Memorial Award in recognition of outstanding work for several years in pictorial photography.

PSA Service Medal Award for the encouragement of work for the Society and photography.

David White Award for outstanding contributions in the field of stereo photography.

Motion Picture Division Grand Award for the film judged best in the annual contest by the Division.

Harris B. Tuttle Family Film Trophy.

Dick Bird Trophy for the best nature motion picture.

The La Belle Award for outstanding contribution to color photography.

Society of Photographic Engineers (Founded in 1948)

The progress award plaque of the Society of Photographic Engineers is an embossed silver medal mounted in a circular black wooden support. It was first awarded in 1954 to Dr. C. E. Kenneth Mees in recognition of his prodigious achievements in the advancement of the science of photography.[4]

SPECIALIZED AWARDS RELATED TO PHOTOGRAPHY

The American Society of Photogrammetry (Founded in 1934)

This Society has established the following awards[5] recognizing advancement of knowledge in photogrammetry:

The Photogrammetric Award, first given in 1944, is intended to stimulate the de-

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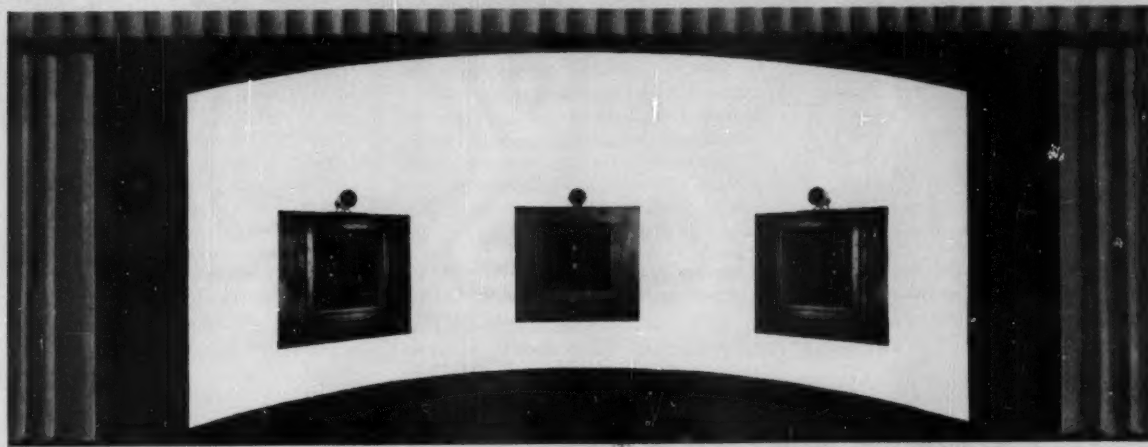

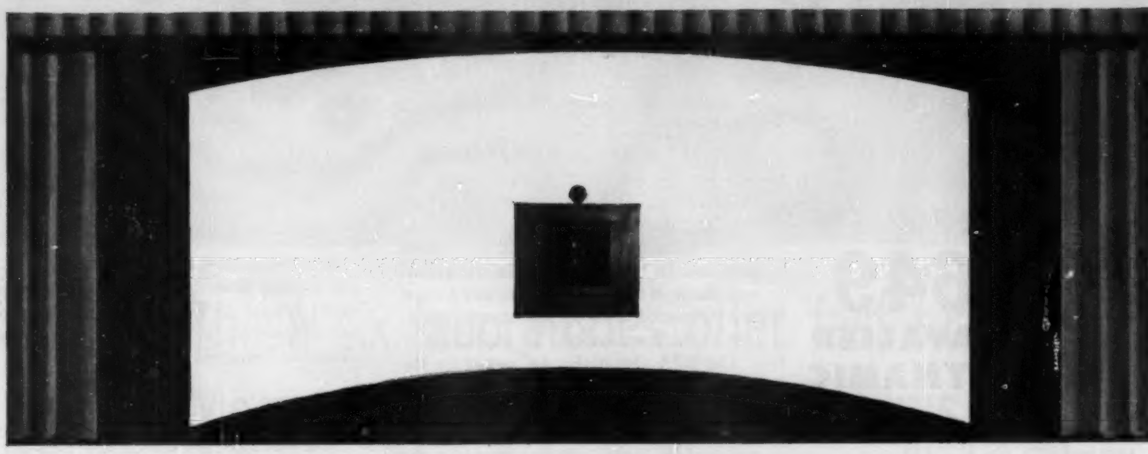

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velopment of the art of aerial photogrammetry in the United States. It consists of a silver plaque mounted on a wooden panel. The recipient retains it for only one year but receives permanently a replica plaque of bronze. The award is restricted to members of the Society.

The Talbert Abrams Award, first given in 1946, is intended to encourage the authorship and recording of current and historical engineering and scientific developments in photogrammetry. The recipient receives the sum of one hundred dollars, a permanent medal and has possession of the trophy for one year. The award is restricted to members of the Society.

The Bausch & Lomb Photogrammetric Award is intended to stimulate an interest in photogrammetry in college students in the United States and to recognize meritorious students who display outstanding ability and interest in photogrammetry. The award consists of a first prize of one hundred dollars and a 3-year paid-up membership in the Society and two second prizes of fifty dollars each plus one-year membership in the Society.

Biological Photographic Association (Founded in 1931)

An *Annual Award* of this Association was established in 1948. It is made for achievement and contributions in advancing biological photography.[6] The award consists of a scroll and a jewelled gold key. In 1953, the name of the award was changed to the Louis Schmidt Award as a memorial to one of the founder members of the Association.

The BPA also makes an award for the most outstanding paper published in their Journal each year and another for the best paper presented at the annual convention. Gold keys are given to the recipients of these awards.

National Press Photographers Association (Founded in 1946)

This Society established in 1949 the Joseph A. Sprague Memorial Award, which is the highest honor given by the NPPA.[7] The award recognizes "unusual service rendered or achievement beneficial to Press Photography by any individual *not* a working Press Photographer." It may also be presented "To the individual responsible for an outstanding technical advance in tools or processes of Press Photography."

The award is in the form of a bronze plaque and an illuminated scroll. In addition a gold ring may be presented to the maximum of three annually to "the working Press Photographer who advances, elevates, or attains unusual recognition for the profession of Press Photography by his conduct, initiative, leadership, skill or devotion to duty." These five Sprague awards can be granted each year if achievement be of sufficiently high standard.

Other awards by the NPPA are as follows:

Merit Award in recognition of outstanding service to the cause of photo journalism to individuals irrespective of whether they are or are not engaged in the field of Press Photography.

Burt Williams Award in recognition of 50 years or more of active work in the field of news photography. Membership in NPPA is not required.

Joe Costa Award to a member of NPPA who does the most each year to advance the aims and objectives of the association.

The Photographers Association of America (Founded in 1880)

In 1951, this society made the first presentation of its George Harris Award, a sculptured metal, which may be presented annually to not more than one professional photographer who has achieved the most for professional photography during the preceding year.[8] The recipient does not need to be a PAA member and nominations can be made by any member of this society. The candidate must be a man of high personal integrity who has served the profession in one way or another, either in unusual photographic skill or through a knowledge and/or application of technical phases of photography.

Honors and Degrees

It is recognized that several of the organizations described in this article also grant honors or degrees. No attempt is made, however, to list these honors as the article is restricted to awards.

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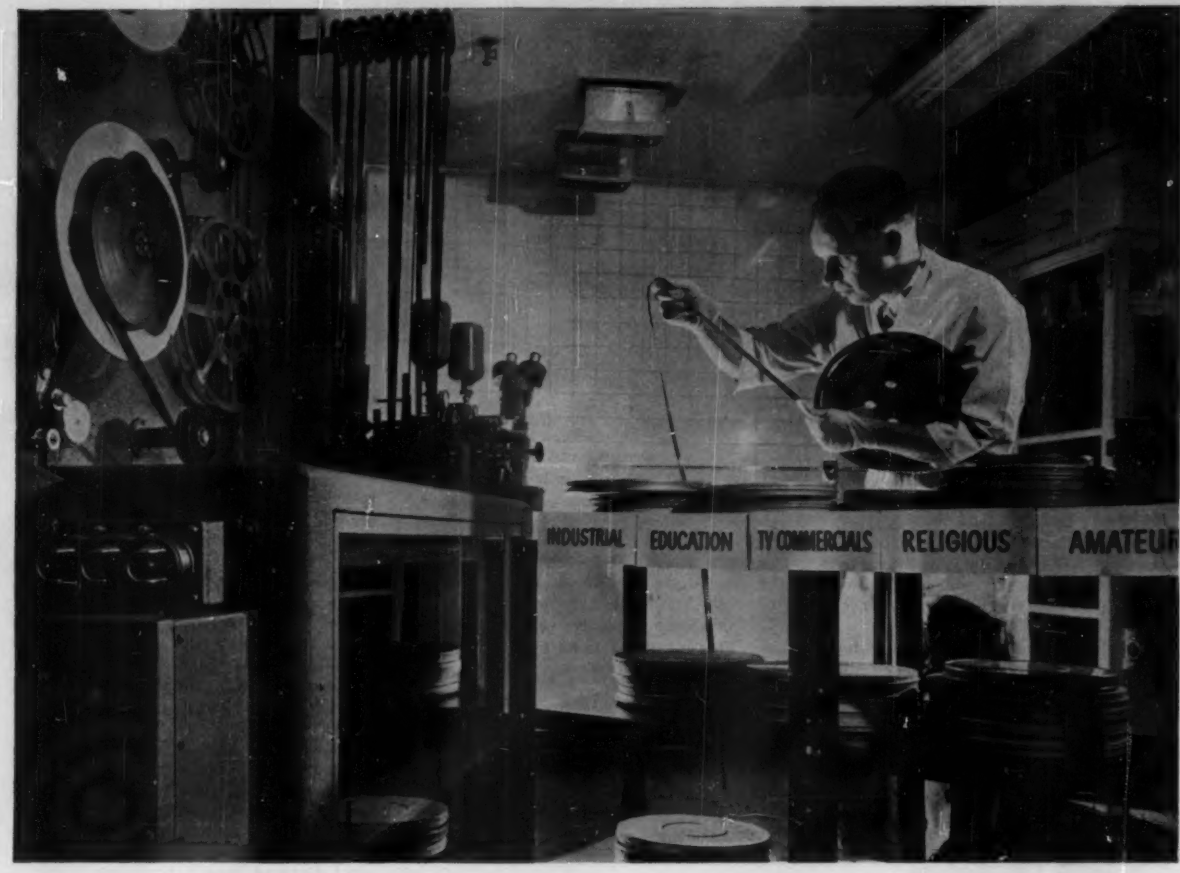
1. *Jour. SMPE, 18:* 41, Mar. 1932; also *ibid. 24:* 378, Apr. 1935; *ibid. 60:* 435, Apr. 1953; *ibid. 65:* Pt. II, 16–18, Apr. 1956.
2. *PSA Journal, 15:* 406, July 1949.
3. *PSA Journal, 20:* D6, Jan. 1954.
4. *Phot. Engineering, 5:* 146 (1954).
5. *Photogram. Eng., 20:* 232 (Apr. 1954).
6. *J. Biol. Phot. Assoc., 17:* 64, Dec. 1948; also *ibid. 18:* 41, Feb. 1950; and *Med. Radiog. and Photog., 25:* 47, 1949.
7. *Nat. Press Photographer, 5:* 12, 17, July 1950.
8. *Nat. Photographer, 3:* 19, Sept. 1952.

"From Cave to Camera" is the title of one of six articles in Socony Mobil Oil Co.'s publication *Oil-Power* for July 1956 that tell the story of color film production. The articles, illustrated in color, give a brief survey of how color film base is made and discuss packaging, photosensitive emulsions and quality control. A 2-page illustration shows the operation of a color film plant. This issue of the magazine has special interest for persons of all ages who are not film manufacturing specialists and who are curious about the story back of the finished product.



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Education, Industry News

National Carbon Co.'s multimillion dollar laboratory at Parma, Ohio, dedicated September 18, 1956, is designed primarily for basic research in chemical and solid-state physics. The company is a division of Union Carbide and Carbon Corp. which, in 1955, spent approximately $43 million on research.

The buildings are located near the center of a 126-acre plot and contain 175,000 sq ft of floor space. Designed for extreme flexibility, with provisions for expansion, the main laboratory building consists of 158 laboratory modules, or individual research units, fully equipped with all the usual service lines plus unusual features necessitated by the type of research, such as lines distributing rare gases. Supplementing the laboratory facilities are adjacent wings housing the chemical engineering and laboratory furnace areas, machine shop, dispensary, a library with a 12,500-volume capacity, cafeteria, locker and shower rooms, boiler and compressor rooms, and administrative, clerical and business offices.

An auditorium is designed to double as a laboratory and projection room for research on light sources for the motion-picture industry. The auditorium is long and narrow, so that light may be projected 100 ft onto a large screen. This arrangement makes it possible to achieve the general sort of projector conditions found in neighborhood-type theaters and to conduct studies of Cinerama-type wide screens.

The auditorium's projection booth includes three openings for projectors, one for 16mm film, one for 35mm film and a spotlight-arc unit for slides. In the booth are two outlets, 500 amp circuits, to supply power for standard and experimental arcs, buttons to raise or lower the screen by automatic remote control, and a control panel for a rack of photocells to measure brightness distribution over the surface of the screen. A door of the booth opens directly to a large laboratory for basic research on carbon arcs. One of the most important problems under study involves two special instruments, a recording spectro-

radiometer and a recording spectrometer (illustrated above).

The boiler and compressor room is on the ground floor and occupies a space 84 by 88 ft, with a ceiling height of 30 ft running up through the first floor. Major equipment consists of two natural-gas-fired boilers, with liquid Pyrofax standby, and two 400-ton refrigeration units. These units, together with six others in various areas, provide 1,000 tons of refrigeration. Chilled water from the refrigeration units is pumped through heat exchange coils in a number of air supply units located in various penthouses on the roof of the laboratories. From those supplying the laboratory areas, 750 cu ft/min of electronic filtered air at 58 F is delivered to each one of the 158, 12 × 24 ft modules. This air is warmed as needed by a thermostat-controlled reheat coil in each module and is then exhausted to the outdoors without any recirculation.

This makes it possible to use toxic chemicals in any module and the air is then exhausted through a hood rather than a ceiling fixture. Other air-conditioning systems in the laboratories are used for specific purposes, such as one that supplies the modules where electrical brush testing is conducted.

The Biological Photographic Association held its 26th Annual Meeting August 27–31 in the Powers Hotel, Rochester, N.Y. The first session was a Color Symposium. Among the papers presented were: Fundamental Factors Affecting Color Films by Howard C. Colton, Color Products Information Section, Eastman Kodak Co.; Adjustment of Color Temperature of the Illumination for Photomicrography With Color Films by Roger P. Loveland, Kodak Research Laboratories; Using Combinations of Color Compensating Filters, Charles G. Brownell, Medical Sales Div., Eastman Kodak Co.; Anscochrome, Its Photographic and Processing Characteristics by James E. Bates, Processing Development Laboratory, Ansco; Comparison in Quality and Cost of 35mm, 2¼ by 3 in., 4 by 5 in., and 5 by 7 in. Photomicrography in Color by Jack Fason, Medical Illustration Service, Veterans Administration, Denver; Color Filters with Multi-Layer Coatings by Harold H. Schroeder, Scientific Bureau, Bausch & Lomb Optical Co.

Dr. Alfred N. Goldsmith has been appointed consultant for *Electronic News*, a weekly industrial newspaper that Fairchild Publications, Inc., plans to publish, beginning early in 1957. Dr. Goldsmith has been editor or editor emeritus of the *Proceedings of the IRE* since 1912 except during 1929 when he served as president of the Institute of Radio Engineers. He was elected SMPTE President in 1932 and has served as chairman of various sectional committees of the American Standards Association.

John S. Boyers has been appointed Manager of Engineering for Bell Sound Systems, Inc., Columbus, Ohio. He is a member of this Society and also a member of the Institute of Radio Engineers and of the Acoustic Society of America. Before his present appointment he was Chief Engineer for Magnetic Memory and Audio Devices, National Co., Inc., Malden, Mass.

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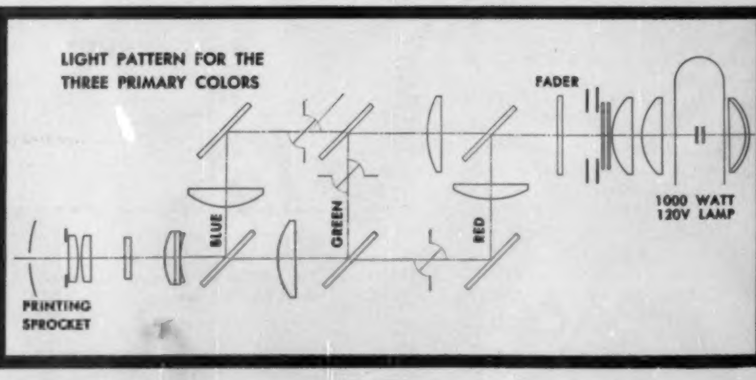

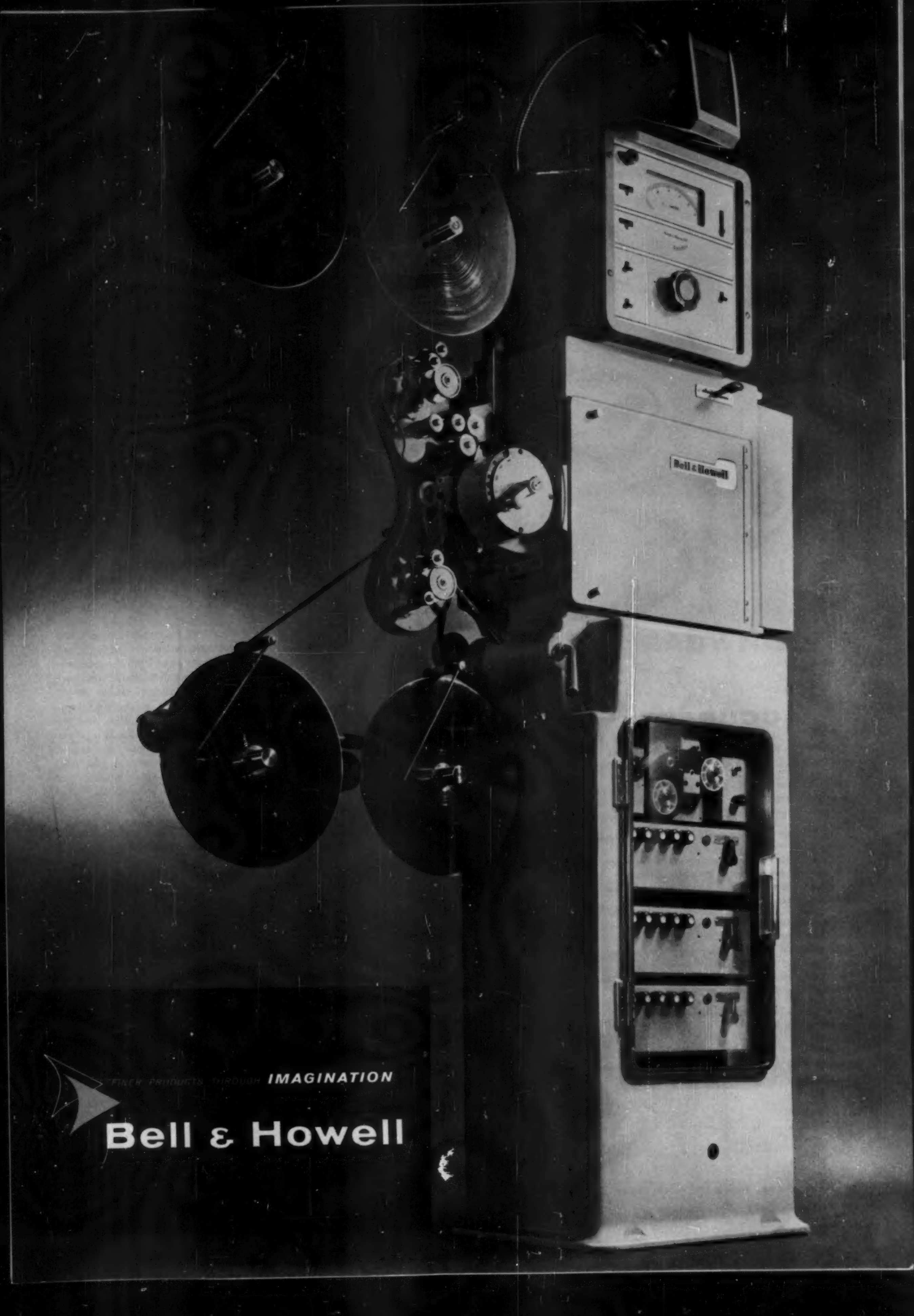
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Densitometry Meeting

Densitometers and densitometry constituted the subject of a symposium of the Scientific and Technical Group of the Royal Photographic Society of Great Britain held April 28, 1956, at the Imperial College of Science and Technology, South Kensington, England.

Among the papers read before the group were: "An Automatic Densitometer," by R. J. Hercock and G. Sheldrick; "A Densitometer for Colour Print Materials," by P. B. Watt; "Balance-Indication and Density Range Extension in a Split-Beam Densitometer Using Low Frequency Beam Chopping," by D. M. Neale; "A Method of Driving a Chopping Disc at Slow or Moderate Speeds," by E. A. Harvey; "A Simplified Treatment of the Relation Between Diffuse and Specular Density," by P. G. Powell; and "Densitometers and Densitometry," by S. L. Fulton and G. Syke.

An Automatic Densitometer

In presenting this paper, Mr. Hercock discussed the necessity for accurate densitometry in photographic work and described the limitations of early densitometers. In one of the earliest photoelectric densitometers two mutually perpendicular beams were taken from a lamp, one passing through the unknown specimen and the other through a calibrated optical wedge. After diffusion, both beams entered a double-windowed photocell which was connected to the grid of a triode valve, the variations in anode current of which were shown by a galvanometer. A mechanical shutter presented each beam alternately to the cell and by adjusting the reference wedge, equality of intensity was indicated when no deflection of the galvanometer spot resulted. Thus the value of the unknown density could be obtained from that of the reference wedge.

Disadvantages of this machine are (a) the light falling on the photocell depends upon the density of the specimen, (b) the sensitivity decreases as density increases, although this may be partially compensated, (c) the switch from one beam to the other cannot be made smoothly, and the galvanometer "kicks," (d) the d-c circuit is liable to cause drift of the galvanometer spot, and (e) manual balancing introduces a possible "operator error" at high densities.

In the present instant these have been overcome as follows: (a) the measuring wedge and unknown density are in the same beam so that as the unknown density is increased the density of the measuring wedge is decreased and therefore both beams are kept at constant intensity; (b) by virtue of this modification the sensitivity is constant throughout the whole range; (c) a single beam is split into two by a rotating mirror; (d) the amplifier is a-c instead of d-c; (e) the movement of the wedge is controlled by a motor which responds to the photocell, eliminating errors in estimation of balance point.

The optical system was shown diagrammatically. The light from a lamp is alternately reflected and transmitted by a 3,000-rpm rotating mirror, one beam passing through a small wedge to form the reference level, the other passing through the unknown density and the measuring wedge. If the beams differ in intensity, a 50-c signal will be obtained from the multiplier, and the wedge can be adjusted until the two beams are equal, when the signal disappears. Over-adjustment gives a signal 180° out of phase with the first and by comparison with the 50-c reference voltage the direction in which to move the wedge is determined.

He explained that in the electrical circuit the output from the photomultiplier is fed to a cathode follower, which is in turn coupled to an a-c amplifier with a push-pull output. The output from the amplifier is fed to one field of a small induction motor, the other field being fed from the a-c mains. Depending on whether the signal voltage is ±90° out-of-phase with the reference voltage, the motor will rotate in one direction or the other. This motor drives the measuring wedge in such a direction as to restore the balance of the optical system, the system being electrically damped to avoid oscillation or overshoot. The measuring wedge is also coupled to a stylus over a typewriter ribbon and graph paper, and when balance is established, depression of a foot switch plots the point. When the plot has been made a pawl releases one step of a ratchet cut to correspond to log E intervals of the exposing device, and the paper is moved to the next position.

Densitometer for Colour Prints

Mr. Watt reported that the specification

of the machine were that reflection densities up to 3 should be recorded with an accuracy of 0.01 for $D = 0$ to 1, 0.02 for $D = 1$ to 2, and 0.1 for D greater than 2, and that interference filters could be used as well as gelatin filters. The simplest achievement of this was to use a lamp of constant brightness, the reflected light falling on a photocell, the amplified nonlinear signal being indicated by a meter designed to give an almost linear density calibration.

The convention of illuminating normally and collecting light scattered at 45° to the normal was employed. In order to obtain high photometric efficiency without use of beams of large angular width, an annular collector was used to pick up all light scattered at 45° to the normal. This was achieved by making the collector a narrow zone of an ellipsoid of revolution, this zone containing the minor axes. Thus when the paper is placed at one focus of this ellipsoid, the light reflected converges at the other focus, the width of the zone limiting the light to that reflected at 45 ± 6° to the normal. This collecting surface was approximated to a circular cross section of appropriate radius of curvature without loss of efficiency, and was made from chromium plated brass, Mr. Watt showing how this surface had been generated on the lathe.

The illuminating system follows conventional lines, including colour filters and a sector wheel to modulate the light at 100 c. Phase sensitive detection is used instead of a bridge rectifier to avoid the bottom bend in the characteristic of the latter. The meter gives an almost linear density calibration from D = 0 to 1 and by altering the amplifier gain this can be extended from D = 1 to 2, and it is necessary to use the nonlinear scale only above D = 2.

Balance-Indication and Density Range

Mr. Neale opened his remarks with a brief survey of variations in split-beam null deflection methods, stressing the necessity for the chosen technique to have good stability and sensitivity which is uniform over the whole density range.

In the model shown, uniform sensitivity is achieved by connecting the photocell directly to the grid of an electrometer valve, and since the grid current is an exponential function of the grid potential this, and to a fair approximation the anode current, are logarithmic functions of the light intensity incident on the photocell. Typical results were quoted for this circuit using a sampling beam of less than ½-in. in diameter, uniform sensitivity being obtained up to D = 1 dropping by 20% at D = 2. With a ½-in. sampling beam, it is easy to maintain uniform sensitivity to D = 3.5.

The circuit is, however, a d-c amplifier and controls must be applied to eliminate changes in mean galvanometer deflection at different densities, and the galvanometer "kicks" as the beams alternate. These limitations are removed by a three-position sampling switch in synchronism with the continuously rotating beam chopping shutter. This circuit was described at length, the action of the sampling switch being demonstrated by comparison of waveforms. With a chopping frequency of 7 c, the difference between the cathode potentials is readjusted abruptly fourteen/sec. A moving coil microammeter has sufficient inertia to smooth out these steps, and the balance indicator appears to respond to the balancing control of the densitometer smoothly and accurately.

At high densities the photocell passes very little current and behaves as a very high resistance. With other factors this represents a time constant so large that a rectangular grid waveform cannot be preserved with chopping frequencies above 10 c. In practice the 7 c adopted gives instantaneous response and also makes it easy to filter out mains hum or ripple in the lamp supply. Consequently a-c supplies may be used for lamp and valve heaters.

By addition of further density extension circuits it should be possible to obtain even greater range of uniform density but this has yet to be tried, the results so far being a densitometer using only three thermionic valves with substantially uniform sensitivity up to D = 4.5 with short and long term stabilities of the order of 0.002 density x units.

Densitometers and Densitometry

Mr. Sykes described from the professional designer's viewpoint the elements of a photoelectric densitometer, and Mr. Fulton discussed the need for a reliable densitometer and how the Baldwin Vacuum Cell Photometer could meet the need.

The papers presented at the Symposium will be published in the Journal of Photographic Science by the Royal Photographic Society, 16 Princes Gate, Kensington, London S.W.7.

Television by Middle Way

One of Europe's most progressive countries is also one of the most backward in the development of television. This paradoxical situation obtains in Sweden, a country often pointed to as a model of progressiveness both technologically and culturally.

The story behind the lag in television is one of bureaucratic negativism and the failure of governmental and commercial interests to come to an agreement. It was hoped that a new proposal presented to the Swedish government in January 1956 by representatives of Swedish trade and industry would end the stalemate. The compromise plan, based partly on studies made by the Swedish Institute for Economic and Social Research, provided for joint financing by government and private interests and governmental supervision of commercial programs. If the plan were approved it would make television accessible to more than two million viewers in three of Sweden's largest cities within a year.

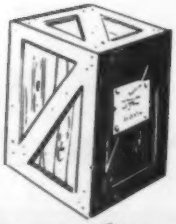
Unfortunately for the success of the plan, the Swedish Minister of Communications promptly introduced a bill (February 9) rejecting commercial television, providing for State monopoly, limiting telecasting to the Stockholm area and setting license fees at \$15.00 per receiver. The bill described the compromise plan as "over optimistic."

Sweden's television story began in 1947 when a joint committee of State officials and representatives of private firms was formed to explore the possibilities of television in Sweden. The committee decided to build an experimental TV transmitter in Stockholm. In 1950 the Swedish Board of Telegraphs and the Swedish State Broadcasting Co. asked the government for a grant of 2.2 million crowns (about \$440,000) for the purchase of experimental equipment. The government refused the grant. Instead, a State commission was appointed the following year to inquire into television.

In 1952, the commission asked the Government for funds to start some television activities in 1954. The Government said, "No." The following year a group representing private interests asked the Government for permission to start an independent commercial TV station where the emphasis would be on cultural programs. The Government again refused. A proposal for a nation-wide network, based on a lengthy report from the commission, was presented to the Swedish parliament in 1955, but was tabled. In 1954 a Swedish film producer was granted permission to stage a commercial "television week," with the aim of demonstrating the social and cultural value of TV, but a request to continue the broadcasts on an experimental basis for six months was refused. In June 1954, the Government withdrew the right it had granted the Board of Tele-communications to permit TV broadcasts, and allowed the State Radio Co. 450,000 crowns from license funds to conduct television research. Experimental programs of one or two hours a week were introduced by State Radio on Oct. 9, 1954, a few days before the publication of a lengthy report from the Government commission created in 1951.

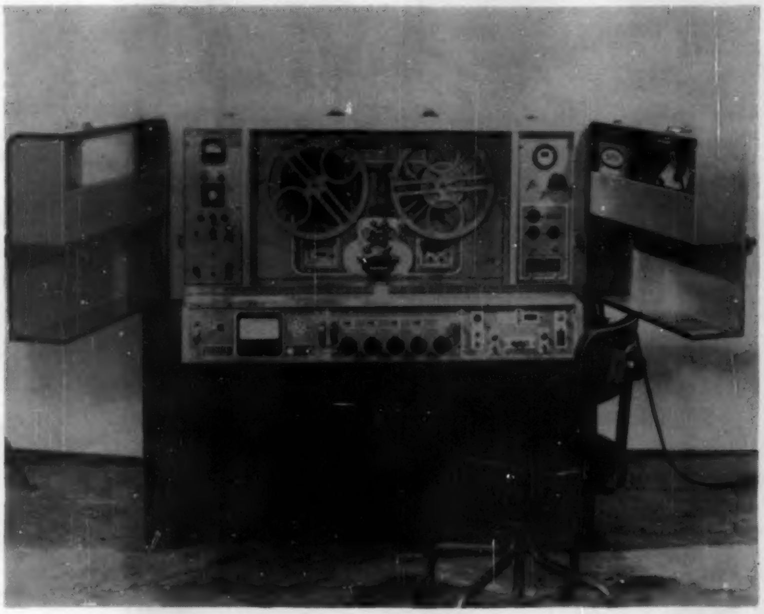
The 1956 compromise plan on which industry bases its hopes seems reasonable enough. One of its provisions that would be approved by at least a few Americans limits advertising to a maximum of 10% of the total viewing time of any program, and advertising would be permitted only at the beginning and end of a program. However, the consent of the Swedish Government to even a modified program that would open the door to commercial TV seems far from assured. And a few thousand Swedes who live in the southern part of the country are viewing Danish broadcasts and those who live in and near the Capitol may view the experimental programs sent out by State Radio while the perhaps irresistible force of industrial progress struggles with apparently immovable bodies of government.—*R.H.* (From information from the Swedish Industriens Presstjänst)

A Conference on Electrical Techniques in Medicine and Biology will be held November 7 to 9 in New York. The Conference is sponsored jointly by the American Institute of Electrical Engineers, the Institute of Radio Engineers and the Instrument Society of America. Papers on electrical and electronic techniques in Biology and Medicine will be read and discussed. General Chairman of the Conference is Dr. E. Dale Trout, X-Ray Dept., General Electric Co., 4855 Electric Ave., Milwaukee.



new products (and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

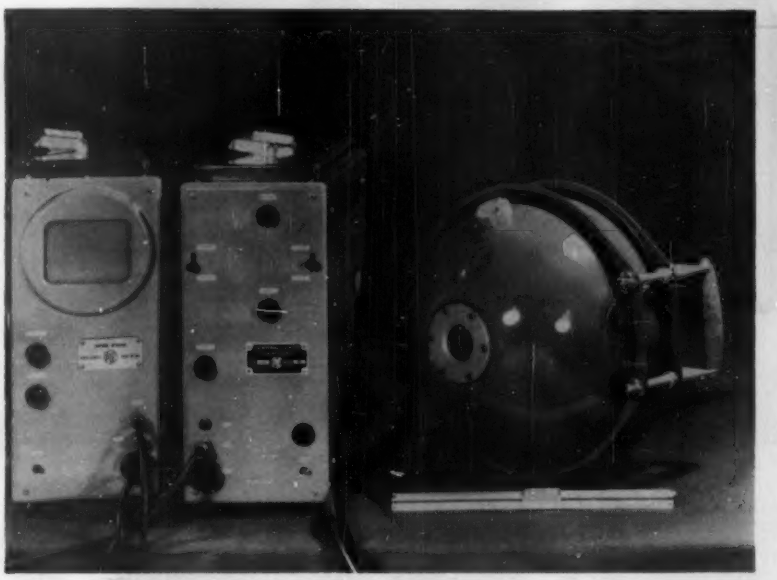


The MARK IX Safari Console is a combination self-blimped studio console, magnetic film, sound channel which can be secured to a single-wheel trailer for mobile field operation. The console cabinet includes a new Magnasync MARK IX push-button operated film transport mechanism, with line-level record-play amplifier designed for operation with any quality line preamplifier. The transport is recessed into the cabinet with ½-in. Lucite doors to complete the sound blimping. The remote panel for the battery-operated rotary generator is located at the right of the transport and a miniaturized field test set including an audio-oscillator, oscilloscope and vacuum-tube volt meter is at the left.

The mixer and remote control assembly is detachable from the transport console. This portion of the system includes a 4-channel microphone mixer with VU monitor and complete remote control of the film transport, including Selsyn interlocked remote footage counter. Integrated with the single-wheel trailer frame is an enclosure for the battery-operated rotary generator, which delivers 500 w of sound-filtered 110 v, 60-cycle power. This power supply features camera "dummy load" and power factor correction for 110 v, 60-cycle synchronous Mitchell camera motors, and manual frequency control. The MARK IX recorder was shown for the first time at the 80th SMPTE Convention Equipment Exhibit in Los Angeles earlier this month.

An electronic relay and a thermistor telethermometer are new products of the Arthur S. LaPine Co., 6001 S. Knox Ave. Chicago, 29. The electronic relay, designed to be safe for water-bath operation, has a 4-way function switch to give flexibility of application. High-wattage loads, such as immersion heaters, incandescent or infrared heaters, refrigerating units, solenoid valves and motor-driven devices, can be operated by low-current sensing elements such as mercury-column thermoregulators or pressure-operated switches. The telethermometer is a portable thermistor-actuated thermometer used in laboratory field research, clinical investigations and industrial remote temperature indication. A single flashlight battery will power it for around 2000 hours of operation.

A booklet on fixed-output constant voltage d-c power supplies is available on request from Sola Electric Co., 4633 W. 16 St., Chicago 50. The 8-page booklet is 8½ × 11 in. and will fit a standard ring binder. The booklet is illustrated and gives technical data for six standard-design, regulated d-c power supplies for intermittent, variable, and pulse loads, or high-amperage loads. Information on Sola's special design and assembly service for custom-made units is included in the booklet, together with instructions how to get additional data or estimates on special design problems.



A TV camera 12 in. in diameter weighing 38 lb on land and buoyant in the water, has been designed by Pye Ltd., Cambridge, Eng., for underwater television. The container for the camera unit consists of two Duralinox hemispheres held together entirely by external air or water pressure. A Staticon pickup tube is used in the camera unit to convert the optical image to an electrical signal. The 14-in. picture monitor is self-contained and other monitors may be added at will.

The camera is intended for operation down to a depth of 250 ft but is designed to withstand a water pressure of 220 psi, corresponding to a depth of 500 ft.

A larger version of the camera is encased in an aluminum sphere 19 in. in diameter, weightless in water and designed to operate at a depth of 3000 ft. The underwater cameras are used to direct salvage operations and are applicable to submarine engineering, marine biology, oceanography and other underwater activities of academic and practical interest.

The larger camera may be suspended by cable from a moving ship, or propelled by an electrically operated cradle. It would be possible to launch it from a submerged submarine and operate it by remote control.

The Stancil-Hoffman Corp., 921 N. Highland Ave., Hollywood 38, has announced detachable flange reels for 16mm, 17.5mm and 35mm sizes. The 1200-ft reel has a removable flange which allows the raw stock to slip over the reel hub and the flange is then set in place by a half turn to a firm locking position. The reel is made of aluminum so that magnetic film may be erased and safely handled. While the space between the flanges is the same for 16mm and 17.5mm film widths, the reels bear different model numbers because of the mounting hole size. A through square hole is used in the DG16 and a $\frac{1}{16}$ round hole in the DF17 and DF35.

The firm also has introduced an Oscillator Wand, Model AO11, designed as a maintenance tool for fixed and portable magnetic recording equipment. The wand is a source of either a 1000-cycle tone or an 8000-cycle tone. When it is held close to the playback head, either a 1000 or 8000-cycle tone will be induced into the playback head to check operation of the playback amplifier or film phonograph. Held close to a dynamic microphone or any other moving coil pickup, the wand will induce the same tones. The wand may also be inserted in the input of a microphone preamplifier in order to record 1000 or 8000 cycles. It measures 8 in. in length, $1\frac{1}{2}$ in. in diameter, and weighs 9 oz. Prices start at $43.50.

Elgeet Optical Co. has issued a 24-page booklet describing its products. The booklet includes lens models, descriptions, schematics, catalog numbers, features and prices. Special sections explain how to mount the lenses on various types of cameras, and specialized application of the firm's equipment. The booklet, entitled "Elgeet Lenses and Optical Accessories for the Finest in Photography," is available upon request to the company at 838 Smith St., Rochester 6, N.Y.

Steinheil Optical Works, 705 Bronx River Road, Bronxville 8, N.Y., has announced that the $f/1.5$ Steinheil Quinon 1 in. (25mm) lens for 16mm motion-picture cameras is available from American distributors. The company is a branch of the Munich firm. The Quinon features a click-stop diaphragm with a wide range of 10 aperture settings. A dual focusing scale is provided with focusing from infinity to $1\frac{1}{2}$ ft. The lens is priced at $79.50.

A Transportable Automatic Tri-Film Processor is available from the Norden-Ketay Corp., 99 Park Ave., New York. Known as Type T246 MK 3, it is designed to process various sizes of films and is equipped with wheels and handles to permit easy transportation. It is 54 in. long 22 in. wide and 51 in. high; weighs 400 lb and has a process capacity of 1 to 4 rolls 16mm, 1 or 2 rolls 35mm, and 1 roll 70mm; length to 400 ft at a rate of 1½, 3 or 6 ft per min. It has temperature-control for solutions and dryer, processes perforated or plain film, and can be operated in daylight except for the loading of film into the magazine.

A 5-ton camera, reported to be the largest ever built on the West Coast, will be manufactured by Gordon Enterprises, North Hollywood, for the Air Force Flight Test Center at Edwards Air Force Base, Calif. The camera measures 25 ft in length and uses a 30-in. lens.

A revised "Kodaguide Movie Dial," for use with Kodachrome, Plus-X and Tri-X movie films, has been announced by Eastman Kodak Co. The dial shows the proper lens openings for the four most common outdoor light conditions: bright sun, hazy sun, cloudy bright, or open shade. Tests conducted by the company have resulted in a new setting of $f/11$ for Kodachrome and Plus-X film which will give good overall results with bright sun on sand or snow. Another dial shows correct indoor exposures for either floor lights on stands or lamps on a camera bar with suggestions for correct lighting. Copies of the "Kodaguide Movie Dial" are available from Kodak dealers for 25 cents each.

An Engineering Data Wall Chart which gives tables on decimal equivalents, temperature conversion, current ratings and other useful information is available from Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif., if a request is made on your letterhead.

Correction

The OPTO Multi-Splicer and OPTO Serial Marker are products of OPTO Mechanisms, Inc., 216 E. 2nd St., Mineola, L. I., N. Y. and are distributed by the Photographic Analysis Co., 100 Rock Hill Rd., Clifton, N. J. The latter company was mistakenly referred to as the producer in the September *Journal*, p 529, where these items were described and illustrated.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Experienced photographer seeks job with industrial firm. Write to: James W. Chipman, Fennimore, Wisconsin.

Television Program Assistant. College Graduate, B.S. Business Administration. October graduate from SRT-T.V. School, Programming & Production. Background in music, including both radio and television experience. Also, five years of summer dramatics with both acting and direction experience. Directed fifteen closed-circuit shows and have thorough skill with RCA cameras (black-and-white & color), RCA boom, switching units, etc. Available October 15, 1956. Morton Eisgrau, 63 Fremont St., Harrison, N.Y.

Audio-Visual Technician. Young man, married, recently separated from service, seeks position as an audio or visual engineer. Background in electronics. A.A.S. in Electrical Technology, First Class Radio Telephone License. Served as Broadcast Engineer with the Armed Forces Radio Service. Desires a position with organization in the New York City area. Complete résumé upon request. Sheldon Pivnik, 2129 East 14 St., Brooklyn 29, N. Y.

Television Film Director-Motion Picture Cameraman-Film Editor. Over five years experience in television film operations, now employed, desires connection with organization active in film production. Owns own motion-picture camera and film editing equipment. Active member SMPTE. Single with car, free to travel. Best references. Require thirty days notice to present employer. Frank E. Sherry, 1505 North Summit Ave., Tyler, Texas. Tel. 2-6132.

Technical Film Sales Consultant. Thorough grasp of production technique;. cinematography, recording, editing, animation, lab procedure; twelve years' experience, technical, sales and administrative; former independent producer; versatile, mature, disciplined, 35 years; available 7-31-56. What have you to exploit "rare bird" potential? Write: CMC, c/o Volksoff, 172 West 4th St., New York 14.

Positions Available

Kodachrome Laboratory Manager. Berkey Photo Service, largest photofinisher for color and black-and-white in the U.S., requires services of man capable of taking full responsibility for installation of complete processing equipment for 35mm still and 8mm and 16mm cine films, and for supervision of all personnel. Must have knowledge and experience for all necessary controls. Position will be open in early Fall of 1956. Five-figure salary to start. Bright future. Please write full details of your experience and references. Replies will be kept confidential. Write to: B. Berkey, Berkey Photo Service, 77 E. 13 St., New York.

TV Development Engineer. Start $10,000. Leading TV receiving antenna manufacturer located in metropolitan N.Y. offers excellent opportunity for experienced development engineer to head antenna research division. Will be responsible for overall supervision of company's antenna development program. Commercial design experience plus creative talent essential. All answers handled in strictest confidence. If qualified, send résumé or call collect Mr. Williams, DEwey 1-1000, 6101 16 Ave., Brooklyn, N. Y.

Optical Printer Operator, experienced, needed by fast-growing optical house in New York. Write: Room 302, 1657 Broadway, New York 19.

Writer-Director for technical and engineering films dealing with intercontinental Navaho missile and associated systems and equipment. College graduate with film production training preferred. Three years' experience writing and/or directing factual industrial films required. Good salary and company benefits. Work in Los Angeles and Florida. Write: E. F. Brunetti, Engineering Personnel, North American Aviation, Inc., Downey, Calif.

Cameramen and Film Editors for technical and engineering films dealing with intercontinental Navaho missile and associated systems and equipment. Three years' experience for cameramen and two years' experience for film editors (male or female) required. Good salary and company benefits. Write: E. F. Brunetti, Engineering Personnel, North American Aviation, Inc., Downey, Calif.

Physicists, Photo-Optics. For research and development on tasks in metric photography, infrared systems, visibility and related instruments. Location: Northwest Florida or Chicago, Ill. Positions at junior and senior levels. Address replies to: Chicago Midway Laboratories of the University of Chicago, Eglin Air Force Base, Fla.

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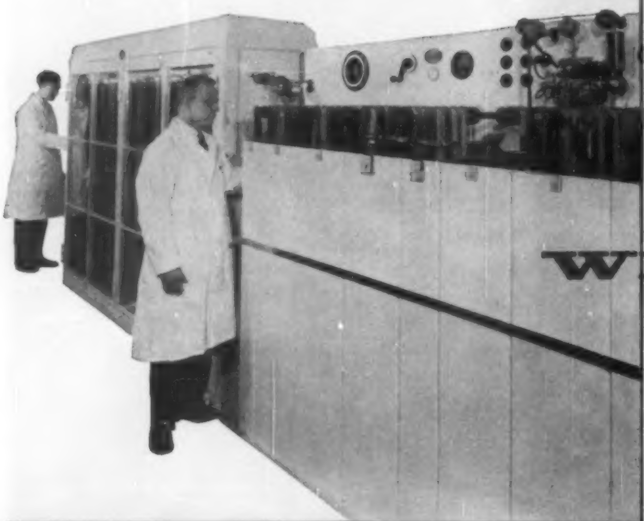

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News Columns

Advertisers

Meeting Calendar

Optical Society of America, Oct. 18–20, Lake Placid Club, Essex County, N. Y.

American Standards Association, Annual Meeting, Oct. 22–24, Hotel Roosevelt, New York

Ninth Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 7–8, Governor Clinton Hotel, New York

National Electrical Manufacturers Association, Nov. 12–16, Traymore Hotel, Atlantic City, N. J.

Acoustical Society of America, Nov. 15–17, Los Angeles

3rd National Symposium on Reliability and Quality Control in Electronics, Jan. 14–16, 1957, Hotel Statler, Washington, D. C.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 21–25, 1957, Hotel Statler, New York.

American Institute of Electrical Engineers, Summer General Meeting, June 24–28, 1957, Montreal, Que.

Radio Engineering Show and IRE National Convention, Mar. 18–21, 1957, New York Coliseum, New York.

American Institute of Chemical Engineers, Dec. 9–12, Hotel Statler, Boston, Mass.

81st Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29–May 3, 1957, Shoreham Hotel, Washington, D. C.

82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 4–9, 1957, Philadelphia-Sheraton, Philadelphia.

83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21–26, 1956, Ambassador Hotel, Los Angeles.

84th Semiannual Convention of the SMPTE, Oct. 20–24, 1958, Sheraton-Cadillac, Detroit.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6–10, 1959, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1956 Journal.

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